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Fire Management Notes

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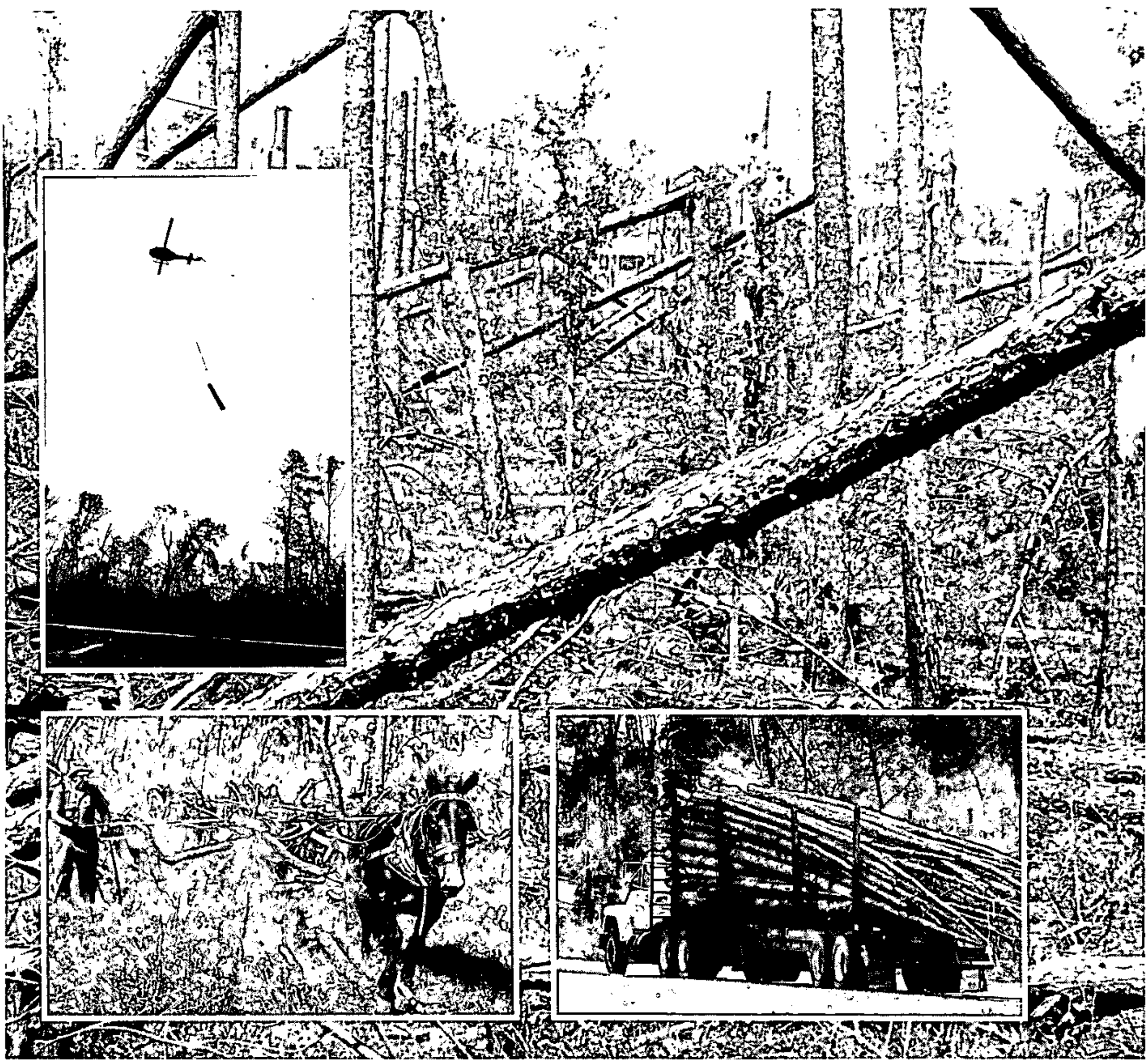

Fire Management Notes

An international quarterly periodical devoted to forest fire management

United States Department of Agriculture

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Contents

Short Features

Tribute to Robert D. Gale

The article on the next page, "The 1990's: Decade for Natural Disaster Reduction," is one of the last pieces Bob Gale wrote before his death in a plane crash on November 26, 1989. It is fitting that Bob's last message concerns the International Decade for Natural Disaster Reduction, a project that he believed in very deeply. At the time of his death, Bob was providing staff leadership to this program, which is intended to help minimize the effects of major natural disasters on human life and property.

Bob worked for the USDA Forest Service for 21 years, beginning as a fire lookout in Idaho. He earned a master's degree in watershed management from the University of Montana and a doctorate in economics from Michigan State University.

Among the milestones of Bob's career was the major study he conducted of the costs and benefits of fighting forest fires. His work was instrumental in bringing economic analysis into fire protection program development and management. He was widely known in the fire management community for his work with State forestry organizations.

Bob's private plane crashed into a mountain in northern Tennessee as he was traveling to a national meeting of Forest Service fire planners in New Orleans. He was taken from his family and friends at the young age of 48, but at least he was pursuing two of the activities most dear to his heart—flying his airplane and practicing forestry through his work in cooperative fire planning. ■

William L. McCleese, *assistant director for planning, USDA Forest Service, Fire and Aviation Management, Washington, DC*

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Front Cover:

Hurricane Hugo blowdown on Francis Marion and Sumter National Forest in South Carolina.

The 1990's: Decade for Natural Disaster Reduction

Robert D. Gale

Cooperative Fire Protection Program manager, USDA Forest Service, Fire and Aviation Management, Washington, DC

The decade of the 1990's has been designated by the United Nations as the International Decade for Natural Disaster Reduction (IDNDR). To mitigate the effects of disaster, the IDNDR program will focus on applying existing knowledge to reduce injury, death, and property damage from natural hazard.

The United Nations urges that each country establish its own decade disaster reduction program. The U.S. Congress passed a joint resolution supporting this international effort and strongly endorsing the establishment of the United States Decade for Natural Disaster Reduction (USDNDR), "as a means of supporting the goal ... to enhance existing cooperative efforts and promote new cooperative efforts to reduce the devastating impact of natural hazards in the United States and throughout the world."

It is important that the United States participate vigorously in this international disaster reduction program for several reasons. Despite its affluence, its significant research and improved knowledge base in some technology areas, and its many governmental agencies and private groups working toward hazard mitigation, losses from hazards are rising in the United States. The United States is at risk from every major natural hazard—earthquakes, volcanic eruptions, landslides, severe weather, tsunamis, flooding, wildfires, droughts, and insect infestations.

The Nation also has a much greater capability than is currently being utilized—improved knowledge base in science and technology, improved sensors and telecommunications, and better informed administrators and public about common elements in hazard mitigation for many types of disaster—to reduce risk effectively and at low cost. Even with their extensive organization and coordination systems, the fire community found out in the 1988 Greater Yellowstone Area fires that even more advanced planning such as the statutory authority to reimburse firefighters from other countries would have been helpful in that firefighting effort. Chief of the USDA Forest Service, F. Dale Robertson, observed about the Yellowstone experience in his speech to the International Wildland Fire Conference in Boston, MA, on July 24, 1989, "As I found out last year, you cannot afford to wait until you're in the midst of a crisis to make cooperation work."

A U.S. National Committee, made up of representatives from such agencies with significant responsibilities in hazard mitigation as the U.S. Geological Survey, National Oceanic and Atmospheric Administration, and Forest Service, and those agencies with a more specialized role such as the National Institute of Standards and Technology, Environmental Protection Agency, and Department of Energy, has been formed to carry out the work of USDNDR. The following four objectives to reduce losses have tentatively been identified:

- Mount a campaign to create an awareness of the impact of natural hazards and the potential to reduce risk significantly
- Emphasize disaster prevention and preparedness
- Stimulate and share expertise, technology, and insight with others at home and abroad
- Develop research and transfer the results for practical use to reduce losses

Program proposals for the USDNDR include two broad types—new and ongoing efforts by individual agencies and organizations and interagency multihazard efforts. Some interagency initiatives include the following:

- Building a national awareness campaign that includes working with local governments and the private sector to increase understanding of what can be done
- Development of an all-hazards assessment and warning capability
- Development of a common interagency system for emergency response and recovery teams with common terminology, organizational structure, and prearranged logistical support, capable of expanding and contracting with the severity and magnitude of the disaster

The USDNDR presents an opportunity to reduce natural hazards at home and abroad through an intensified effort at increasing awareness of the hazards and how to mitigate them, greater cooperation and sharing among governmental agencies (Federal, State, and local), and wider and more effective application of knowledge. It also is an opportunity for the fire community to capitalize on a major national and international effort. By joining forces with the disaster community at large, in pursuit of a set of common goals and objectives, we can increase our available resources for seeking solutions to fire problems such as the wildland-urban interface, arson, and major fire disasters. ■

Fire Management on the Frontier: An International Perspective

Robert W. Mutch[1]

Program manager, USDA Forest Service, International Forestry Staff, Disaster Assistance Support Program, Washington, DC

Widespread forest fires have occurred repeatedly this past decade, causing the loss of life, property, natural resources, and agricultural crops. In addition, fires have contributed to the deforestation of tropical forests and released large amounts of carbon dioxide into the atmosphere. Indonesia, Australia, the United States, China, the Soviet Union, Mexico, and Canada have all had their trial by fire in recent years. The Ash Wednesday fires occurred in Australia in 1983, burning 840,000 acres (340,000 ha), killing 77 people, injuring 3,500 people, and destroying about 2,500 homes. Fires burned approximately 10 million acres (4 million ha) in the tropical forests of East Kalimantan in Indonesia during the severe drought of 1982 and 1983. A series of fires in the United States in 1985 killed 44 people and destroyed 1,400 homes at the urban-wildland interface. China also was plagued by several devastating fires in May 1987. The China fires burned over an estimated 2 to 3 million acres (800,000 to 1,200,000 ha) in the forested northeastern part of the country, consuming 12,000 homes, leaving 60,000 people homeless, and killing over 200 people. Harrison Salisbury, the noted author, appropriately titled his book on the event "The Great Black Dragon Fire—a Chinese Inferno."

Reports showed that large fires north of the Amur River in the Soviet Union were burning an additional 9 to 15 million acres (3.5 to 6 million ha) at the time fires in China were causing so much damage. Over 5 million acres (2 million ha) burned in the Western United States and Alaska in 1988, 250,000 acres (100,000 ha) burned in 1989 from Hurricane Gilbert blowdown in southern Mexico, and a record 16 million acres (6.5 million ha) burned in Canada in 1989. Other parts of the world have not gone untouched as wildland fires have caused the loss of natural resources in the Caribbean, South America, France, and Spain.

A new international focus on wildfire prevention and preparedness programs clearly will be a high priority to reduce the threat of fires to people, property, natural resources, and agricultural crops.

This pervasive pattern of global wildfires, whose smoke plumes and flaming fronts were observed from satellites hundreds of miles above the Earth's surface, has galvanized the attention of a worldwide audience. The terms "deforestation" and "global warming" have become household expressions, an interest manifested on the covers of major publications. Probably most people could recount by now that the buildup of carbon dioxide from forest fires and other greenhouse gases can trap heat near the Earth, causing the atmosphere to warm. People are concerned about the effect of potential warming on future fire regimes. A new international focus on wildfire prevention and preparedness programs clearly will be a high priority to reduce the threat of fires to society and natural resources and perhaps reduce threats to the very health of the planet. Emerging initiatives to improve global cooperation in fire management will be explored.

International Fire Management Assistance

The U.S. Government, through the U.S. Agency for International Development (USAID) Office of U.S. Foreign Disaster Assistance (OFDA), responds to a wide variety of disasters throughout the world every year. As mandated by Congress, OFDA provides assistance not only for international disaster relief and rehabilitation, but also for disaster preparedness, early warning, and mitigation. The Director of OFDA reports directly to the USAID Administrator, who is the President's special coordinator for international disaster assistance. OFDA's three geographic divisions—Africa and Europe; Asia and the Pacific; and Latin America and the Caribbean—provide country-specific expertise to respond to relief and preparedness needs in each region. OFDA also has an Operations Support Division that is responsible for coordinating relief activities during a major disaster.

Recently OFDA has been responding to requests for emergency assistance to about 50 disasters a year and monitors another 40 situations annually that could become disasters. When disaster strikes, OFDA mobilizes Government

[1] Mr. Mutch presented this paper at the Fire Working Group session at the Society of American Foresters National Convention held at Spokane, WA, on September 24–27, 1989. It originally appeared in print in the Proceedings of the 1989 Society of American Foresters National Convention, Forestry on the Frontier; 1989 Sept. 24-27; Spokane, WA. Pub. No. 89–02. Bethesda, MD: Society of American Foresters; 1990: 70–73.

resources and coordinates its response with that of voluntary agencies, international organizations, and other donors. OFDA has provided assistance to wildfire disasters in Argentina, Australia, China, Costa Rica, Dominican Republic, Ecuador, Guatemala, Italy, and Mexico since 1983. Although other types of natural disasters, like droughts, earthquakes, floods, and severe storms, affect greater numbers of people, the continuing severity of wildland fires raises serious societal and environmental concerns. OFDA recognizes that meaningful responses to these concerns must address fire prevention and preparedness measures, as well as direct disaster relief assistance.

Forest Service Support to OFDA

Cooperation between OFDA and the USDA Forest Service was formalized in 1985 when an agreement between USAID and USDA Office of International Cooperation and Development established a Disaster Assistance Support Program (DASP) within International Forestry of the Forest Service. DASP is funded by OFDA to provide that office with disaster prevention, preparedness, technical assistance, and emergency relief support for all types of natural disasters. Program objectives include:

- Provide support in prevention, preparedness, and operational planning for natural disasters
- Strengthen disaster planning and training for OFDA, Department of State Foreign Missions USAID Missions, and host countries
- Provide OFDA with the capability to identify and access natural disaster-related technical experts and disaster management specialists
  - Assist in the planning and coordination of workshops, conferences, studies, and publications that promote effective disaster prevention, disaster preparedness, and disaster management measures
  - Augment the disaster relief efforts to OFDA, Department of State Foreign Missions and USAID Missions, and host countries with technical experts and disaster management specialists on a short-term basis

As the objectives indicate, DASP provides individuals to OFDA for technical assistance or emergency assignments. In addition to Forest Service personnel, recent assignments have included representatives from the Department of the Interior Bureau of Land Management and National Park Service, Department of Commerce National Weather Service, and State agencies in North Carolina, Oregon, and South Dakota. Other agencies, consultants, private individuals and companies, and university personnel with disaster management experience also may be recruited for assignments.

One way that OFDA has strengthened the capabilities of countries to respond to wildfires has been through the sponsorship of international fire suppression courses for Latin America. Taught entirely in Spanish by Latin American, Spanish, and United States instructors since 1983, the courses were designed to teach basic fire suppression skills and reduce the threat of wildfires to people, property, and natural resources. Since the courses were taught in a train-the-trainer mode, course participants have returned home to offer similar training to hundreds of other trainees. The courses also have fostered a new spirit of self-reliance and cooperation in the region, as people establish new networks of mutual trust and rapport among countries. Similar wildfire suppression courses have been patterned after the Latin American experience and offered in Ghana and Indonesia. A Food and Agriculture Organization consultant also was able to take the OFDA-sponsored Indonesian course to the Philippines in June 1989 and train 30 additional participants in the fundamentals of wildfire suppression. Personnel at the National Advanced Resources Technology Center in Marana, AZ, have played a key role in the design and production of these courses.

The Forest Service also has been able to provide valuable on-the-job training assignments for course graduates on U.S. fire crews. Individuals from Argentina, Brazil, Chile, Ghana, and Indonesia have had the opportunity for firsthand experience with fire management organizations in the Southeast and Western United States.

An emergency operations management course also was designed, developed, and offered to 30 participants from the Caribbean and Latin America in 1989. The course used emergency management principles, case examples, and simulation exercises to improve the coordination and management of disaster relief efforts. Patterned after the Incident Command System in the United States, the course proposed an all-risk organizational structure to manage the important functions of operations, planning, logistics, and finance at disaster sites.

Exploring Global Cooperation—the 1989 Boston Conference

To bring together international leaders in natural resource management and fire management to explore and strengthen opportunities for cooperation, OFDA served as one of the sponsors of the International Wildland Fire Conference in Boston, MA, July 1989. The conference, "Meeting Global Wildland Fire Challenges," also was sponsored by the National Fire Protection Association, the USDA Forest Service, Forestry Canada, the U.S. Department of the Interior, the Mexican Forest Service, and the National Association of State Foresters. Over 400 participants from 39 countries met in Boston to, in the words of Deputy Minister Jean Claude Mercier, Forestry Canada, "initiate a new era in the management of wildland fire around the world, an era marked by cooperation and consultation throughout the global village." Delegates not only were challenged by noted speakers to seek opportunities to work more effectively together, but also participated in roundtable discussions to share their fire management ideas with others. Closing speaker John Goodman, Ministry of Natural Resources, Ontario, Canada, listed the six key groupings of the roundtable discussions:

- Wildland fire is the symptom of more serious social and economic problems. The answer may not lie in more technology, but in treatment of the social or economic malaise
- Development of regional fire cooperative agreements
- The exchange of fire management personnel at all levels
- Development of formal communication networks among countries
- The standardizing of international training, equipment, and communications
- Improvement in the distribution of fire data among nations

Goodman also called for the immediate formation of a working group given the responsibility of preparing an action plan based on the ideas and energy generated at the conference. He said that the working group should establish a formal link with the United Nations through the United Nations Disaster Relief Organization (UNDRO) to capture the opportunity presented by the International Decade for Natural Disaster Reduction's (IDNDR) declaration resolution.

The 1990's—a Decade Dedicated to Reduction of Natural Disasters

Philippe Boullé, Director of the New York Office of UNDRO, indicated at the Boston Conference that the main objective of the International Decade is to reduce loss of life, property damage, and social and economic disruption caused by disasters through concerted international action. He listed the five goals of IDNDR:

- To improve the capacity of each country to mitigate the effects of natural disasters expeditiously and effectively
- To devise appropriate guidelines and strategies for applying existing knowledge
- To foster scientific and engineering endeavors aimed at closing critical gaps in knowledge
- To disseminate information related to the assessment, prediction, prevention, and mitigation of natural disasters
- To develop measures through technical assistance and technology transfer for the assessment, prediction, prevention, and mitigation of disasters

Boullé concluded by offering some observations about how the concepts of the Decade might link with wildfire management programs:

- Develop widespread international publicity to improve public awareness of wildfire threats
- Stress the importance of preparedness activities
- Devote attention to hazard assessment, risk management, and appropriate land uses
- Transfer and apply modern advances in science and technology to combat disasters in developing countries around the world

The Fire Management Frontier

A worldwide perspective for fire management cooperation was established at the International Wildland Fire Conference in Boston. Concern about deforestation and global warming has created a favorable climate of support at all levels to build a more balanced fire management program on a global scale. UNDRO's International Decade for Natural Disaster Reduction and other initiatives have provided mechanisms for sharing and transferring appropriate fire management technology to the global community.

What current fire management technology can appropriately be shared with others? Certainly we need to transfer the results of fire research, such as information about fuel models and fire behavior prediction systems. We need to share such information in such a way that it can be useful to a variety of different countries. OFDA recently funded an effort at the Intermountain Fire Sciences Laboratory in Missoula, MT, to translate the BEHAVE fire prediction program into Spanish. The program will be provided for personal computers. It can be introduced at the next International Fire Suppression course. There will be other opportunities to transfer research results to countries that can benefit.

Because of the continued loss of life and the occurrence of fire-related injuries, it is important to renew our vigilance toward the safety of the firefighter and the general public. We need to share the same principles regarding fire threats, fire dangers, and fire survival precautions with the general public we routinely share with firefighters. This effort could be enhanced by translating existing brochure and information into other languages.

In mid-September, people came from all over the world to a meeting sponsored by the United Nation's Institute for Training and Research in Geneva, Switzerland, to determine ways to strengthen the disaster management capabilities of sub-Saharan African countries. Although the target audience for the proposed training was the mid-level manager, the group determined that senior government officials and the general public also needed to be informed of their roles and responsibilities in improving disaster management responses. This recommendation reinforced Boullé's observation that widespread international publicity is an important undertaking to improve the awareness of society toward disasters.

Advances in fire prevention, fire use, fire-danger rating, and suppression methods can be actively transferred through international training courses and international exchanges. We need to improve our ability not only to use fire effectively, but also to protect society and natural resources from fire threats.

In 1988, for example, the Forest Service hosted 16 fire management specialists from Argentina in California, Montana, and Wyoming for a 3-week technical exchange. Participants had the opportunity to learn about interagency cooperation in fire prevention, fire training, and fire protection. The Incident Command System also is being adapted for international use in responding to all types of disasters.

In an address in 1988, Thomas Lovejoy, tropical biologist and assistant secretary for external affairs of the Smithsonian Institution, stated, "I am utterly convinced that most of the great environmental struggles will be either won or lost in the 1990's. And that by the next century it will be too late." We will have to wait until the year 2000 to determine how well fire managers rose to the challenge of reducing wildland fire disasters in the decade. We in the global fire management community are in an enviable position to act positively in this struggle because we have the world's attention, the necessary technology to respond, and momentum to build upon the cooperative efforts of the past. ■

South Carolina Forestry Commission's After-Hugo Fire Preparedness

Gloria Green

Writer, South Carolina Forestry Commission, Columbia, SC

In the aftermath of Hurricane Hugo, South Carolina finds itself facing one of the most dangerous forest fire seasons in the State's history. With the tangled masses of trees left by the hurricane, fires could spread rapidly and burn intensely.

South Carolina suffered $1.04 billion in timber damage amounting to a volume of 6.7 billion board feet. With the down-and-damaged timber, homes and lives are more vulnerable than ever to forest fires. "There's a lot more than timber and wildlife at stake," said Stan Clark, fire control staff forester.

Prevention Education

Just days after Hugo's destructive force destroyed acres of the State's timber, the South Carolina Forestry Commission began a post-Hugo fire prevention campaign to educate the public on the increased fire hazard and to help salvage what was left of the State's forests. It was the most concentrated fire prevention campaign ever attempted. With a price tag of over three-quarters of a million dollars, the campaign includes: paid radio-TV-newspaper advertising, a poster effort, street and parade banners, a 300,000-piece direct mailing, bumper stickers, T-shirts, caps, and a school solicitation campaign. Dubbed "GIMME 12," the campaign asks residents to voluntarily avoid outdoor burning for 12 months (fig. 1).

The focus of the campaign and the fire suppression efforts are being aimed at nine of South Carolina's hardest hit counties: Berkeley, Charleston, Clarendon, Dorchester, Kershaw, Lancaster, Lee, Sumter, and Williamsburg (fig. 2).

Preparedness

Presuppression. According to Clark, 90 percent of the Forestry Commission's pre-Hugo fire suppression was done using medium-sized crawlers with plows and blades. With the amount of downed timber following Hugo, however, plows are useless in many areas. Even with blades, movement is slow and maneuverability difficult.

"We've never faced this situation before," said Clark. "We don't know if we will be completely ready, but we're doing everything we can think of to prepare for the situation."

Just days after Hugo's destructive force destroyed acres of the State's timber, the South Carolina Forestry Commission began a post-Hugo fire prevention campaign and fire preparedness effort.

Presuppression of fires was one of the main goals as this year's winter and spring fire season began. The South Carolina Forestry Commission, after securing assistance from the Federal Emergency Management Agency (FEMA), hired temporary personnel and leasing equipment to help prepare for what they are calling

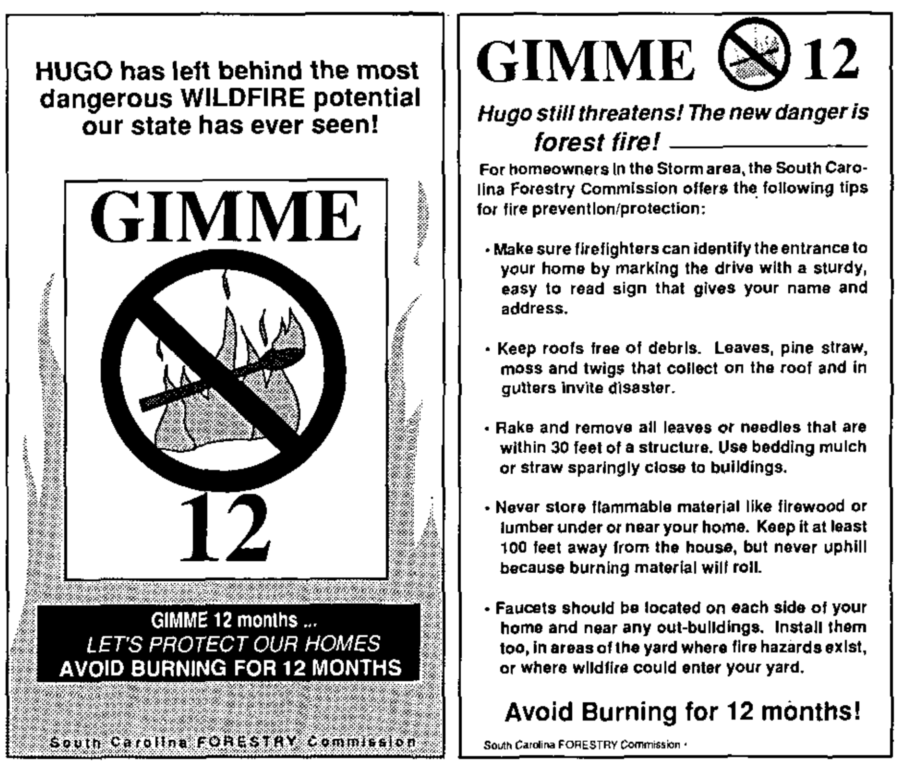

Figure 1—*South Carolina Forestry Commission "Gimme 12" pamphlet, printed in black and white, front and back on a 3½ × 6 inch card.*

the most dangerous fire potential the State has ever seen.

In addition to regular staff and equipment, the Forestry Commission has the help of 12 contracted bulldozer and chainsaw crews. These crews work primarily in presuppression, preparing firebreaks around high-risk communities, hospitals, and homes. If conditions warrant, these resources will also be used to supplement the regular suppression forces on going wildfires.

Air operations are being reinforced as well. Two additional spotter planes have been contracted to supplement the Commission's fleet of detection aircraft, and two CL-215 aerial tankers have beefed up the State's existing helicopter-bucket delivery system. "As far as equipment and personnel, we will be as ready as we can be for this fire season," said Clark.

Firefighting techniques. The Commission is also expecting some major changes in their firefighting techniques. According to Clark, the firefighters will not be able to do as much closeup firefighting as in the past. "We will be using more indirect attack including more use of water and foam," said Clark. "Our rate of attack will be slower going because of having to use indirect methods."

Communication. Communication will play a major role in fire management. In addition to training the new temporary crews, the Commission is holding meetings in the nine counties with local fire departments, law enforcement agencies, and emergency preparedness agencies, to establish objectives and coordinate resources.

Even with an intense fire prevention campaign, fire presuppression efforts, and the most up-to-date fire equipment, South Carolina may not be able to escape serious fires. Though Hugo is gone, its impact on the State will continue for years, stemming from that one night, September 21, 1989, when the worst natural disaster in the United States rocked the State of South Carolina. ■

Figure 2—*Map of Hugo forest fire hazard area (prepared by South Carolina Forestry Commission).*

METAFIRE: A System to Support High-Level Fire Management Decisions

Albert J. Simard and James E. Eenigenburg

Research scientist and computer programmer, USDA Forest Service, North Central Forest Experiment Station, East Lansing, MI

Introduction

The Federal Emergency Management Agency (FEMA) provides funding assistance to States for suppressing wildland fires that threaten to become major disasters.[1] The USDA Forest Service, as principal advisor to FEMA for assessing State fire emergencies, was asked to develop a new process to aid in making fire emergency declarations. As a result, we developed two interrelated systems:

- A nationally applicable fire severity index oriented to large wildland fires that have the potential to become major disasters
- An automated national decision support and executive information system to gather data and transmit daily reports to FEMA decisionmakers

We named the combined systems METAFIRE—a national information system for wildland fire severity. The prefix "meta" means that the system addresses fire problems at a higher level than existing fire-behavior and fire-danger rating systems. A system that can quickly and efficiently address a fire problem involving three agencies, an individual incident, a national-level decision, and a short decision time also has broad application at the middle and upper levels of wildland fire management.

METAFIRE consists of five subsystems: weather data input, large-fire data input, a fire severity index, a central processor, and system output (fig. 1). In this report, we describe and evaluate the severity index—a mathematical model that transforms weather data into large-fire information. We also describe the information system that links weather observations to severity maps on decisionmakers' desks.

Time, Space, and Fire Severity

Was it necessary to add yet another fire-related index to the current proliferation? Examining the scales of existing indexes sheds some light on the question (table 1).

Fire-behavior models are the most precise fire management models available. Although these models are used for planning, frequent on-site weather observations are required to achieve designed accuracy. Detailed fuel input requirements typically limit predictions to specific sites. Fire-behavior models support site-specific, event-oriented decisions.

Fire-danger models dampen fire-behavior sensitivity to reflect average worst conditions over a 500 mi^2 (1,295 km^2) area for one daily cycle. Fire-danger inputs are based on local weather and a set of predetermined fuel types. Fire-danger models support midlevel fire management decisions.

Short-term fire severity[2] further aggregates fire-danger sensitivity. It reflects conditions on a 10,000 mi^2 (25,900 km^2) area for 1 to 3 days. It incorporates synoptic and midterm weather processes; fuels are based on broad fuel classes. Fire severity

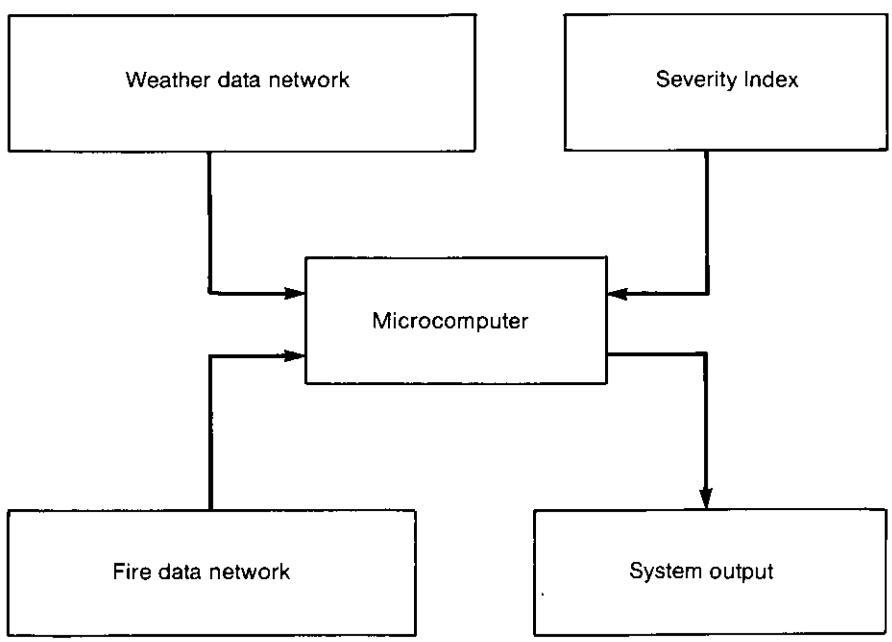

Figure 1—*Flow diagram of the* METAFIRE *system.*

[1]Disaster Relief Act of 1974, Pub. L. No. 93-288, Stat. 417 (1974).

[2]The term "fire severity" has several meanings. As used here, fire severity is oriented to the potential for large fires—events that generally last one to a few days. This differs from the ecological concept of site injury and from the cumulative concept of fire activity over an extended period.

Table 1—*Scale contrasts among the designed best uses of fire behavior, fire danger, and short-term fire severity*

Element	Scale: Fire behavior	Fire danger	Fire severity
Time	1 to 6 hr	6 to 24 hr	1 to 3 d
Space	Site	500 mi² or 1,295 km²	10,000 mi² or 25,900 km²
Weather	On-site	Local	Synoptic
Fuels	Site specific	Fuel type	Fuel class
Use*	Suppression	Preparedness	Emergency
Level	Individual event	District/forest	State/Nation

*Examples of action taken at various scales.

models support high-level fire management decisions.

Moving from fire behavior to fire danger essentially involves reducing the sensitivity of inputs and outputs. This important distinction justifies two separate systems. Moving from fire danger to fire severity involves adding significant new components and concepts. Severity must be averaged over broader areas and longer time periods. Important interests of society, such as fair representation for all States, are not part of existing systems. New approaches will be needed to extend projections beyond the here-and-now of fire-danger rating. We conclude that the advantages of a new severity index outweigh the disadvantages of adding one more complication to the world of fire management.

The Severity Index

The severity index incorporates six components:

- *Spread*—1964 National Grass Spread Index
- *Short-term*—National Fire-Danger Rating System (NFDRS) Ignition Component (fuel model O)
- *Upper air*—stability, moisture
- *Midterm*—NFDRS Energy Release Component (fuel model O)
- *Long-term*—Palmer Z-index
- *Season*—green-up, winter

The index also has three attributes that make up part of the underlying structure:

- *Base map*—National Weather Service (NWS) Climate Divisions
- *Fuel classes*—brush, conifer, deciduous, grass
- *Climatic normalization*—1964 California Fire Load Index

The METAFIRE severity index (version 3.9) captures 82 percent of large fires on 13 percent of all days across the country.

Spread is a key component of virtually every fire-danger rating system ever developed. Locally strong winds are often cited as the reason that fires escape. The 1964 National Fire-Danger Rating grass spread model (Nelson 1964) was the best large-fire discriminator out of 22 spread models tested.

When fuels are cured, a few days of drying coupled with high winds and low humidity are sufficient for a major run. The NFDRS fuel model O ignition component (Bradshaw, Deeming, Burgan, and Cohen 1983) was the best large-fire discriminator out of 26 short-term models tested.

Incorporating upper air data into the index adds a dimension that is unavailable through surface measurements. Also, because air masses typically require a few days to pass a given point, their characteristics provide a longer term and larger scale outlook of conditions than surface data. The upper air component is based on a lower atmosphere severity index for wildland fires (Haines 1988).

The total fuel energy available to the flaming front is a key input to large-fire behavior. The midterm component is based on the NFDRS fuel model O energy release component (Bradshaw, Deeming, Burgan, and Cohen 1983). Because a full evaluation would have required extensive data processing, we simplified our analysis to complete the structure of the severity index quickly.

Major historical fires have often been associated with drought. The monthly moisture anomaly (Z-index) of the Palmer Drought Index (Karl 1985) was the best large-fire discriminator of six long-term indexes tested. The fact that the index was already normalized for the entire country greatly facilitated its use here.

There is an obvious need for a green-up component to dampen fire severity. A weather-based season model was developed specifically for the severity index (Simard, Eenigenburg, Main [in press]). An important aspect involves a weather-based method for determining the start, transition, and end of the fire season. Also, snow on the ground or below-freezing temperatures are important considerations for a year-round system.

A base map structure is needed for organizing the severity index. The Environmental Data Service delineates 353 State Climate Divisions (CD's) for the country (Environmental Data Service 1968). By combining small CD's and splitting large CD's, we ended up with 390 modified CD's with an average area of 9,424 mi^2 (24,408 km^2). The base map also includes all area attributes needed for the severity index (e.g., fuels, elevation, weather stations).

We selected four broad fuel classes: brush, conifer, deciduous, and grass. Finer resolution could not be justified for a large-scale system. Each CD was classified into primary and secondary fuel classes. Fuel-based thresholds were calculated with a weighted average—two-thirds, primary and one-third, secondary.

Fire climate varies by a factor of 4 across the country (Schroeder 1964). Some form of climatic normalization is needed to prevent some areas from always being above the threshold and some areas from always being below it. Starting with a 48-State fire-weather climatology (Schroeder 1964), we repeatedly calibrated each CD until the normalization coefficients adequately balanced good success with an acceptable false alarm rate.

The six components and three attributes span the range of available models. Some are from existing fire-danger rating systems, some have been adapted from related fields, and some have been specifically designed for fire severity. The components and attributes provide a reasonably complete structure for a first generation fire-severity index.

Component thresholds are calibrated to achieve a predetermined distribution of days: low (65 percent), moderate (18 percent), high (10 percent), very high (5 percent), and extreme (2 percent). Each level is assigned a point value: low (0), moderate (1), high (2), very high (3), and extreme (4). We sum the values for all five positive components (maximum value = 20) and subtract the value of the seasonal component (maximum value = 9). We retained fire-danger rating terminology (e.g., high, very high) for classifying component levels, because most components originate from fire-danger rating systems.

The index does not provide more than single digit precision when used operationally. Therefore, the transmitted index is limited to a 0- to 9-point scale. A single digit is also useful for tabulating and mapping 390 CD's on a single sheet of paper. The conversion is accomplished by adding 1 point to the component sum and dividing by 2. We categorized the index into six classes: nil (0), low (1–2), moderate (3), advisory (4–5), watch (6–7), and warning (8–9). The advisory/watch/warning classification differentiates the severity index from fire-danger rating. It follows standard weather service terminology used for severe weather bulletins. For emergency management, the three classes below advisory are lumped into a single class (normal), yielding a four-class index.

Index Evaluation

To evaluate the index, we collected large-fire data throughout the country from June 1987 through February 1989. If a fire grew by 500 acres (202 ha) or more in 1 day, we entered the information into our database. A complex was treated as a single fire. We believe that we accounted for 80 to 90 percent of all large-fire runs during the study period. The fire database consists of 998 fires that made 1,821 runs on 1,262 CD-days (one CD with one or more fires on 1 day). There were 181 CD's (46 percent) with one or more large-fire runs.

We also acquired weather data from 606 NWS network stations across the country and calculated the severity index for all 390 CD's on a daily basis. The weather database consists of a 576-day sample (90 percent of all days) collected during a 21-month period. Although our sample is climatologically inconsequential, we have archived data for 224,640 CD-days—statistically, a highly significant sample.

The index has undergone continuous development throughout the test period. By archiving the data, we are able to approximately reconstruct what the current version of the index would have been by using previous weather. We cannot, however, reconstruct those aspects of the index that use a type of weather data not archived during earlier periods. This report is based on version 3.50 of the METAFIRE system (through Feb. 28, 1989).

The first consideration in evaluating the index is establishing criteria. Our criteria, although subjectively selected, received no negative feedback from several fire managers who reviewed them. To be operationally useful, the index should capture at least 70 percent of all large fires with no more than 20 percent of all days above the advisory threshold. Subtracting the percent of days (cost) from the percent of fires captured (benefit) yields an information value (score) for the index. Our two limits give a lowest acceptable score of 50 for an operational index.

Overall performance of version 3.50 of the severity index is shown in figure 2. Grouping the advisory, watch, and warning classes, 75.6 percent of all fires are captured on 13.2 percent of all days, yielding an index score of 62.4—well above our first criterion.

The nil category includes 0.3 percent of all fires and 33.4 percent of all days. Large fires are rare under such conditions. With 9.8 percent of all fires and 43.7 percent of all days, the low category represents an irreducible "noise" level. Due to weather variability, fire runs not occurring at the reported time or place, or model errors, there will always be a low probability of large fires at low index values. The moderate category includes 14.3 percent of all large fires on 9.7 percent of all days. Although conditions at this level are adequate for large-fire runs, such runs are exceptions more than the rule.

The advisory category contains 9.9 percent of all days coupled with 44.1 percent of all fires. In a statistical sense, we consider this the "enabling" level for large fires. More large fires occur at this index level than at any other because conditions are more severe than at the moderate level and there are 3.4 times more days than at the watch level.

The watch category contains only 2.9 percent of all days but 24.5 percent of all fires. This is beyond the threshold region; conditions are severe by any standard. Preliminary evidence suggests that most FEMA-class fires (those for which application is made for Federal assistance) are associated with the watch category.

Warnings are difficult to achieve with this system. Only 0.4 percent of all days are at the warning level, but 7.0 percent of all fires are at this level. This level represents the extreme in the range of fire environments. Virtually any fire occurring

Forest Service Computer System Can Warn of Major Fires

Press Release, East Lansing, MI, April 26, 1990. A new computer system called METAFIRE, developed by Forest Service scientists at the North Central Forest Experiment Station, East Lansing, MI, monitors current weather conditions and warns of the possibility of fires bigger than 500 acres occurring anywhere in the country.

"Right now our predictions are for the same day," said Al Simard, a researcher at East Lansing who developed METAFIRE jointly with the Federal Emergency Management Agency. "Within 2 or 3 months we hope to be able to forecast 24 hours in advance and within five months to extend that to 48 hours in advance."

The system takes surface and upper air weather data and long-term drought information from 600 weather stations across the country. It also includes the number of fires and acres burned the previous day and computes a "severity index" predicting the probability of a fire larger than 500 acres (202 ha).

To improve the severity index, scientists at East Lansing have added an automated system that takes into account how long the index has been at a certain level, seasonal weather differences, and whether the adjoining State had bad conditions yesterday and the weather is coming your way—all circumstances that can refine the basic index.

During two and a half years of pilot testing, METAFIRE has been 82 percent successful in identifying large fires in the U.S. It was 95 percent successful in August 1988 when it monitored and predicted the Yellowstone fires. The system also warned of the possibility of the "Stockyard Fire" near Escanaba, MI, in 1988, and recently it predicted the catastrophic fires that destroyed 24 houses in the wildland-urban zone near Oklahoma City this past January.

"The system helped us in making the decision to have the Governor decree a Statewide burning ban," said Rob Doye, former staff forester and fire chief for the Forestry Division of the Oklahoma Department of Agriculture. "We don't have fire weather stations in the western two-thirds of the State because of the sparsity of commercial timberland, and METAFIRE was able to fill us in on the weather conditions there," he said.

METAFIRE has been tested by 25 State and Federal agencies since its inception.

under these conditions has the potential to escape.

A second way of measuring performance is to divide the total number of CD-days at a particular index level by the number of CD-days with large fires at that level (e.g., 40:1). The inverse is the probability of a large fire in one CD for a single day (e.g., 2.5 percent). Our second criterion is that the days-to-fire ratio for the advisory class cannot exceed 100:1 (one large fire for every 100 CD-days in this category).

The days-to-fire ratio is shown in figure 3. For the nil category (0), the ratio is 18,750:1, and for low (1–2), 800:1. At the moderate level (3), although the ratio has dropped considerably (120:1), it is still too high to justify more than normal management activity. At the advisory level (4–5), the ratio has dropped to 43:1—well below our maximum criterion of 100:1. At the watch level (6–7), the ratio has further decreased to 21:1, thereby justifying somewhat more prefire activity than at the advisory level. At the warning level (8–9), the ratio is 11:1. With one large fire expected for every 11 days in this category, substantial activity can be justified in an effort to lessen the chance of an outbreak.

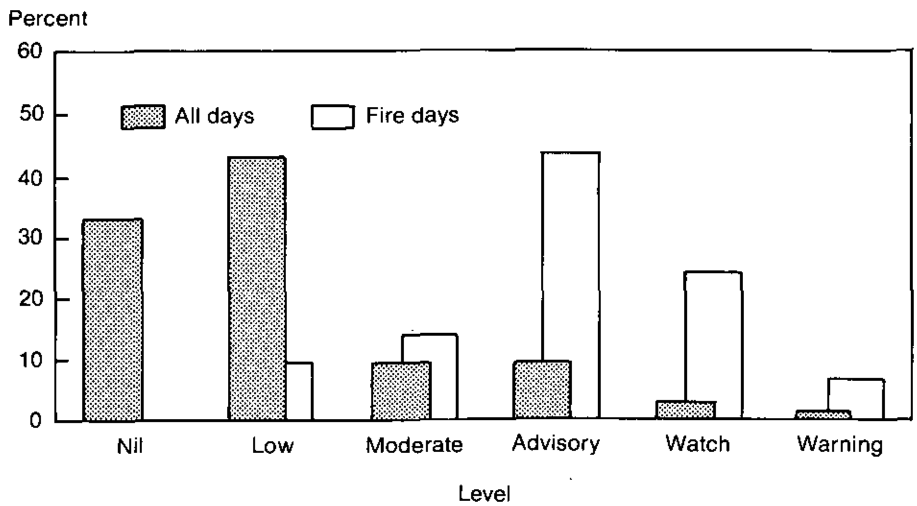

Figure 2—*Percent of all days compared with fire days at specific Severity Index levels (version 3.50).*

The Information System

The information system includes four subsystems:

- *Data processing*—collect, process, and archive data
- *Database management*—develop information retrieval procedures
- *Decision support*—calculate large-fire probabilities
- *Executive information*—highlight key elements graphically

Data processing involves collecting, organizing, and storing data. Our primary data source is a weather station network. Automated Forest Fire Information Retrieval Management System (AFFIRMS) stations are located in areas affected by wildland fires, and the data are currently used by many fire managers. However, most AFFIRMS stations do not operate year round, are sparse in some regions, do not collect some forms of data, report only once a day, and are not as reliable as NWS stations.[3] Therefore, although NWS stations are generally not located in forested areas, their other attributes are essential for a highly reliable, year-round, national system that requires a variety of weather data.

[3]For simplicity, we refer to all stations in the NWS network as NWS stations, although many (particularly hourly stations) are operated by other agencies such as the FAA and Department of Defense.

The data network used by METAFIRE includes:

- 606 hourly stations
- 88 upper air stations
- 171 synoptic stations

Built-in redundancy (two stations per CD and two observations per station) limits the missing data rate to only 0.6 percent. Accessing the data is fully automated; six weather files are retrieved daily; drought data are retrieved weekly. Multiple backup and automated editing procedures permit the program to run despite transmission problems or incomplete data.

The essence of database management is transforming data into information. Average values of the weather elements are used as inputs to severity index calculations. Partially processed data and severity index components are archived for subsequent analysis and reprocessing. Fire data are organized by individual runs, by CD, and by fire. The system generates statistical summaries

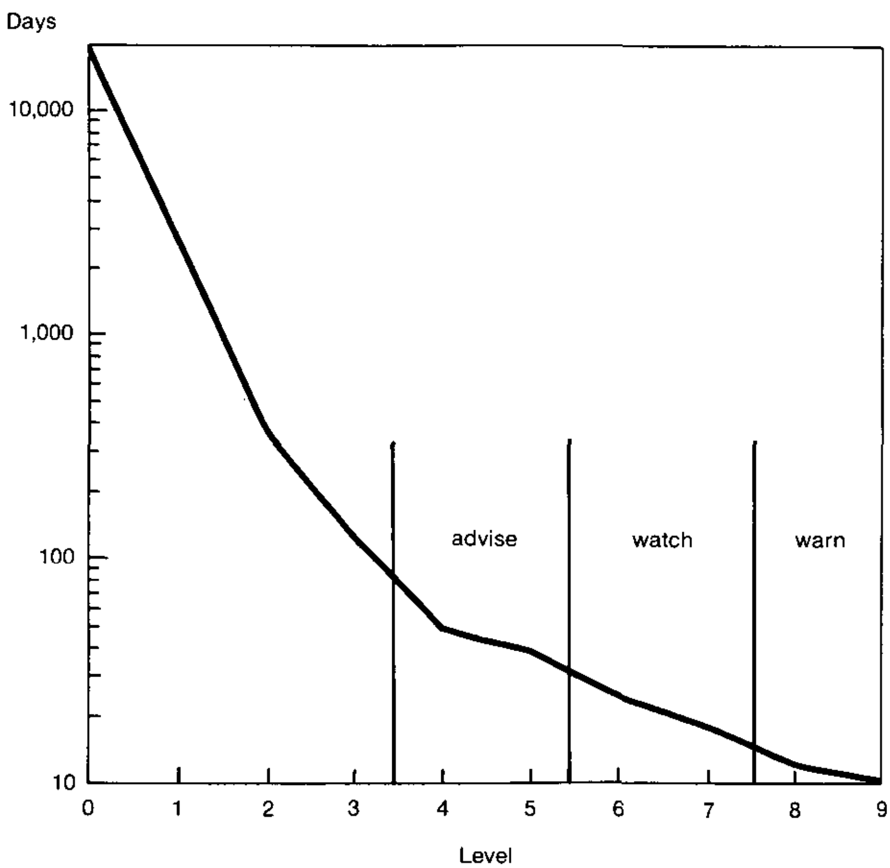

Figure 3—*Ratio of all days to fire days (false alarm rate) for the fire severity index (version 3.50).*

for the country, regions, States, and CD's by month and year, and overall summaries of all data collected since the system first generated the summaries. METAFIRE also has the ability to produce national maps of 23 variables and severity index components for any day in the archive database.

Decision support shifts the emphasis from generic information to a specific decision. In METAFIRE, the severity index is converted into the probability of one or more large fires for individual CD's. We are developing techniques to aggregate the data to provide regional and national large-fire occurrence probabilities.

Executive information systems focus on high-level decisionmakers. METAFIRE transmits a daily severity report that highlights problem areas. The one-page report includes: heading, data, highlights, and summary (table 2). The heading identifies the report and labels the information. The data section lists the severity index for every CD in the country. Highlights identify those CD's at the watch and warning levels. The summary provides a key and tabulates totals for the country.

Graphics capability is achieved through a software package (METAMAP) that adapts the severity report to a commercial mapping package. This permits users with a personal computer to produce national and regional fire severity maps on site (fig. 4). Transmitting data and producing maps locally maximizes both cost effectiveness and flexibility for users.

Operations

The processor begins accessing and processing the first five weather files at 1:40 p.m. e.s.t. or e.d.t.; it begins accessing 2 p.m. data at 2:15 p.m. The severity report is transmitted about 2:25 p.m. For all time zones, conditions are observed at or extrapolated to 1 p.m. local time. Telecommunication or processing problems delay report transmission by 10 to 30 minutes less than 5 percent of the time. Because the large-fire database includes several fires in December and January, METAFIRE operates 365 days per year. In 668 days of operation, the daily report was 1-day late or missing only 0.8 percent of the time. The near real-time system has proved remarkably reliable.

Operating costs of METAFIRE are modest. The major cost is purchasing weather data ($28 per day),[4] followed by the operator's salary ($13—average of 2 hours—per day), telecommunication costs ($7 per

[4]This amounts to only 4.6 cents per station-day.

Table 2—*Selected METAFIRE Severity Index values for September 10, 1988 (version 3.32)*

	Indexes for State Climate Division (CD's) and their Subdivisions[1]										Highlights
State	1 abcd	2 abcd	3 abcd	4 ab	5 ab	6 ab	7 ab	8 abc	9 ab	10	CD's above watch threshold (*indicates warn)
AL	0	0	0	0	0	0	0	0			
AK	0011	3010	0013	1	01	0	0	001	00		
AZ	3	13	1	3	1	3	33				
AR	0	0	0	1	0	0	0	0	0		
CA	55	52	4	2	12	2	44				
CO	65	323	9	58	1						1a, 3*, 4b*
WA	2	1	2	2	2	3	6	7	2	2	7, 8
WI	2	0	1	2	1	1	3	2	1		
WV		0	0	0	0	0					
WY	3	3	67	5	8	8	7	8	6	7	3a, 3b, 5*, 6*, 7, 8*, 9, 10

[1]The letters a, b, c, and d denote subdivisions of the 10 State Climate Divisions. A column entry reports a severity value reading for a specific subdivision. Key: 0–3—normal, 4–5—advisory, 6–7—watch, 8–9—warning. Information for States, Connecticut to Wisconsin, alphabetical order, have been omitted. (Summary for all States, including those omitted in this table: 266 CD's normal, 2 CD's missing, 64 CD's at advise, 41 CD's at watch, 17 CD's at warn.)

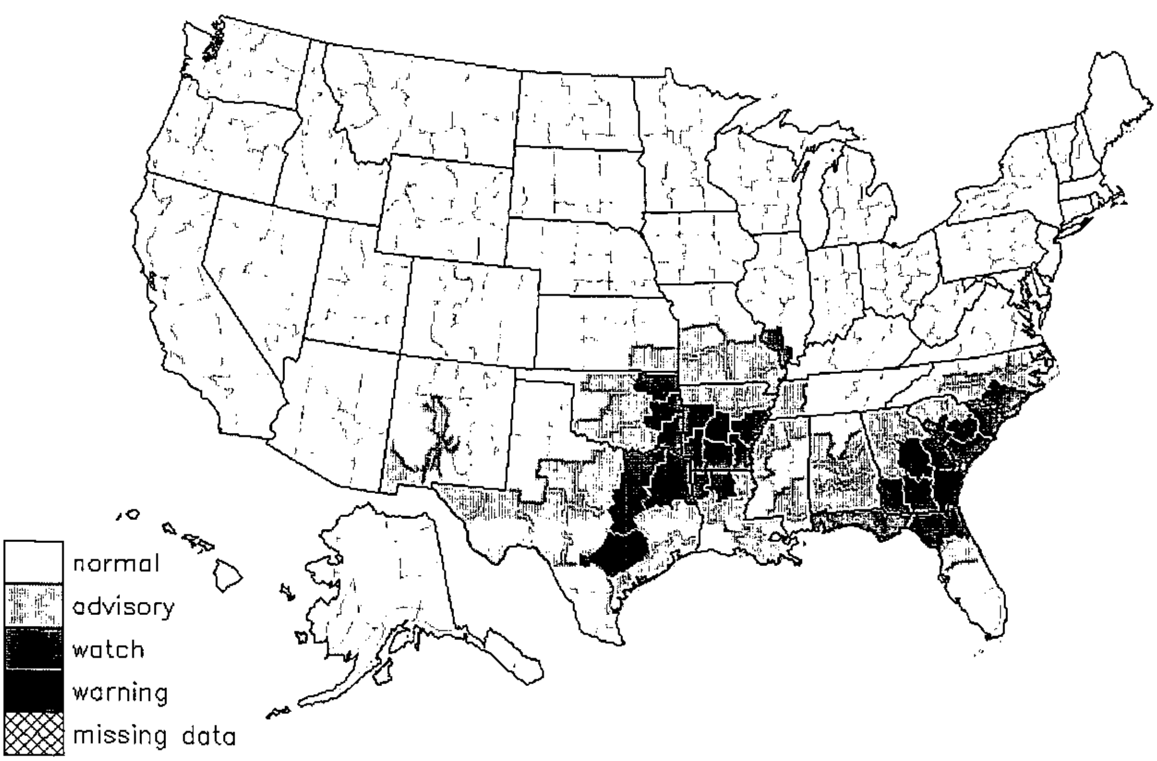

Figure 4—*Sample national fire severity map showing severity levels for January 12, 1990.*

day), and miscellaneous expenses ($2 per day). Thus, the total cost for operating the METAFIRE system is $50 per day. By any standard, METAFIRE is one of the least expensive, near real-time national systems in existence.

Summary

METAFIRE meets or exceeds the rigorous criteria we set. The severity index (version 3.9) captures 82 percent of large fires on 13 percent of all days across the country. Severity information is provided to decisionmakers in near real-time in a readily understandable format. The system is relatively inexpensive to operate and has proved better than 99 percent reliable.

Possible high-level uses for the METAFIRE system include:

- *Emergency management:* Monitoring large-fire potential provides an early alert to agencies involved in managing fire emergencies
- *Pre-positioning:* When combined with forecasting, the system may justify relocating resources before a major outbreak
- *Resource allocation:* METAFIRE could assist in allocating resources between regions with concurrent major outbreaks
- *Prevention:* The system provides a basis for increasing activities where the probability of large fires is highest
- *Public awareness*—Severity maps and other reports are suitable for briefings and public information.

METAFIRE is being operationally tested by national, regional, and State fire and emergency management agencies. Continuing development is expected to further improve system performance as well as add new features, such as 24- and 48-hour forecasting and regional large-fire probabilities. When complete, the METAFIRE system should make a significant contribution to high-level wildland fire management across the country.

A progress report and computer demodisk (requires an EGA (extended graphics) monitor) describing the METAFIRE system in greater detail are available. Contact the authors for further information. ■

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International Disaster Assistance

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Fire and Aviation Management's involvement in international fire management, training, and preparedness activities continues to grow in breadth and importance. These activities promote cooperation internationally—from worldwide sharing of information and technical assistance and a spirit of helpfulness to agreements between neighboring countries, States, or provinces having common interests in fire management or task force assistance for catastrophic events. It is fitting that we recognize this participation, particularly at the beginning of a decade dedicated to reduce the destructive impact of natural hazards throughout the world. This article briefly outlines Fire and Aviation Management's activities.

International Conference

The international wildland fire conference, "Meeting Global Wildland Fire Challenges," was convened in Boston, MA, on July 23–26, 1989, in an effort to examine the reasons for and what can be done about the enormous loss of personal property, life, and natural resources throughout the world, resulting from wildfire. The sponsoring organizations included the U.S. Department of Agriculture (USDA) Forest Service, National Fire Protection Association, Forestry Canada, La Secretaria de Agricultura y Recursos Hidraulicos (SARH), the U.S. Department of the Interior Bureau of Land Management, the U.S. Agency for International Development Office of U.S. Foreign Disaster Assistance (OFDA), and the National Association of State Foresters.

Fire and Aviation Management's activities promote cooperation internationally—from worldwide sharing of information and technical assistance to specific agreements between neighboring countries, States, or provinces having common interests.

This international conference, officially designated by the United Nations Disaster Relief Organization as a predisaster decade activity for the International Decade for Natural Disaster Reduction, brought together 400 experts from more than 35 countries and provided a unique opportunity for participants to meet each other and make initial plans for collaboration. These relationships make it possible for participants to learn more about the severity of wildfire problems around the world, encourage international communication, and increase mutual cooperation among nations. Participants left the conference with a determination to foster and increase international cooperation in fire management.

Fifth International Wildfire Suppression Course Development

In mid-November 1988, Paul Weeden, Washington Office, and Jay Perkins, Pacific Southwest Region, attended the Steering Committee meeting in Madrid, Spain, for the Fifth Latin America Wildfire Suppression Course. The Steering Committee, which met at the headquarters of the Instituto para la Conservacion de la Naturaleza (the Spanish Forest Service), developed a course agenda and budget and selected instructors for the upcoming course, an advanced course intended for graduates of the four previous international fire suppression courses. The committee also inspected the new training facilities north of Madrid. The course is scheduled to be offered in October 1990.

Cooperative Agreement Between a Region and a Mexican State

On July 17-18, 1989, representatives of SARH from the Mexican States of Sonora and Baja California Norte and the Forest Service met in Phoenix, AZ, to review the fire suppression agreement between Region 3 and the State of Sonora. All representatives felt that the current fire suppression agreement establishing firefighting cooperation between Sonora and Coronado National Forest is exceptionally successful and that it is in everyone's mutual interest to expand the current cooperative program. The representatives are currently developing an expanded agreement that will allow each agency to do the following:

- Initiate immediate and appropriate wildland fire suppression action against any fire—within a mile of the international border—threatening life, property, or the natural resources of the other country. (This would apply to all the lands along the international boundary between the States of Sonora and Arizona.)
- Take immediate action to protect life during a wildland fire emergency such as the evacuation of firefighters entrapped by a wildfire.

- Provide technical assistance on wildland fires that are not within a mile of the international border.

In addition to the fire suppression agreement, all representatives agreed to develop a separate agreement and undertake a cooperative plan of work for other forest resource management programs including timber, range, wildlife, and recreation. All representatives agreed that we should work together and develop similar agreements to augment cooperation between the States of Mexico and those of the United States.

Disaster Assistance to Quintana Roo, Mexico

USDA Forest Service Technical Assistance. On September 14, 1988, Hurricane Gilbert blasted the northern coast of Mexico's Yucatan Peninsula with winds that approached 200 miles per hour (322 km/h). It was the first Category 5 hurricane to make landfall in the Western Hemisphere since Hurricane Camille in 1969. The Mexican State of Quintana Roo was particularly hard hit. More than 2.5 million acres (1 million ha) of damaged, defoliated, or uprooted tropical rain forest created a very serious wildfire hazard. The Normatividad Forestal (Mexican Forest Service) requested assistance from the USDA Forest Service to evaluate and mitigate this wildland fire hazard. In October 1988, Roberto Rodriguez and Alfonse Murphy of Region 6 helped the SARH officials develop a decisionmaking process to limit the number of fires, their size, and the impact of the fires on the affected area. The process enabled SARH to make decisions regarding implementation of alternatives identified in fuels management, fire prevention, presuppression, and suppression plans.

North American Forestry Commission Assistance. In November 1988, Normatividad Forestal also requested assistance from its partners—the USDA Forest Service and Forestry Canada—in the North American Forestry Commission, to assess damage to the forest and suggest steps that might be taken to avert a catastrophic fire risk in the upcoming dry season. For 8 days, January 19–26, 1989, the partners inspected forest damage, from the ground and air, and discussed hazard reduction with resource officials.

Suppression Assistance. On July 12, 1989, with large fires burning in the Hurricane Gilbert blowdown near Cancun in Quintana Roo, the Director of Forest Management and Protection of the Normatividad Forestal requested emergency assistance. Two Forest Service employees, John Swanson (California) and Roberto Rodriguez (Oregon) conducted a technical assessment of the situation and helped local officials develop strategy and control tactics. Major progress in controlling the wildfires and organizing the suppression and support effort was reported when the graduates of the previous international fire suppression courses were mobilized and deployed to Quintana Roo.

Fire Training. During the week of October 2, 1989, the Steering Committee for the First Wildland Fire Suppression Course for Quintana Roo met during the week of October 2 to plan, develop, and organize a basic and intermediate fire suppression course for the fire crews of Quintana Roo. The course was taught in January 1990 to about 60 people from several local and national agencies and local communities. This course was a train-the-trainer type; each graduate was qualified to teach basic fire suppression techniques to entry-level firefighters. Pat Velasco, Region 3, was an instructor, cadre leader, and course coordinator for the USDA Forest Service.

Assistance to Baja California Norte, Mexico

On July 6, 1989, the Mexican Government requested emergency assistance through the American Embassy in Mexico City, because a large wildfire, located about 53 miles (85 km) southwest of Mexicali in the San Pedro Martires Forest in Baja California Norte was burning out of control, entrapping eight firefighters and threatening people living and working in the area, an astronomical observatory, and an ecologically important wooded area. (Later it was learned that the eight firefighters were led to safety on July 6.) OFDA asked the USDA Forest Service to provide a technical assessment of the situation and emergency assistance. The Forest Service assisted in developing suppression and control tactics and in coordinating available Mexican fire suppression and logistical support resources within Baja California Norte.

Fire Program Evaluation, Federal District of Mexico

Jim Hickman and Albert Martinez, Region 3, assessed the forest fire management program of the southern part of the Federal District of Mexico and provided recommendations for possible improvement. Specific objectives included:

- Assess the fire management operation, including prevention, detection, suppression, dispatching, and safety, suggest alternatives, and make recommendations
- Provide guidelines to develop a forest fire protection plan

Hickman and Martinez noted major changes and improvements in the SARH fire suppression organization since the SARH personnel attended the international fire suppression courses held at Marana, AZ, in 1983 and 1984 and the international course held in Mexico City in 1988. The fire suppression organization for the Federal District is efficient and aggressive. The number of fires fluctuate with the weather and fire danger, but the acreage burned per fire is steadily decreasing. Mexico's SARH has the professional personnel with the enthusiasm, skills, and aggressiveness necessary to do the job.

Wildfire Training in Costa Rica

Gary Benavidez, Region 1, served as an advisor and instructor at the First National Interagency Wildland Fire Suppression Course in Costa Rica during the first 2 weeks in December. This training course was organized by Luisa Alfaro, training officer for the National Park Service in Costa Rica. Luisa also served as a Steering Committee member and instructor at the Fourth International Wildfire Suppression Course in Mexico City in January-February 1988. Working with Luisa as instructors in conducting this course were several graduates of the Fourth International Wildfire Suppression Course. The Boise Interagency Fire Center sent some tools and firefighting supplies that were used by students during the course.

Technology Exchange with Israel

Our cooperative fire management program with Israel continues to expand. (For background, see Brandel, Rogers, and Reinhart 1988.) During 1989, Fire and Aviation Management Director Lawrence (Mic) Amicarella, Forest Fire and Atmospheric Sciences Research Director William Sommers, and Mount Hood National Forest Supervisor Michael Edrington visited Israel and helped them develop long-term fire research, suppression, and prescribed fire goals. During October, five Israeli management specialists spent 8 weeks in the United States learning about prescribed fire, fire and its role in integrated resource management, and advanced fire management concepts. The fire group visited the national forests in southern California, the Willamette and Umatilla National Forests, and the Pacific Southwest and Range Experiment Station, observing fire management operations and learning firefighting techniques.

Training Assistance to Indonesia

Early in 1988, OFDA requested Forest Service assistance in organizing and coordinating a wildland fire suppression course in Indonesia. Stephen Pedigo, then of Region 8, served as team leader for a cadre of interagency instructors from the National Park Service, the Forest Service, and the North Carolina Division of Forest Resources. The wildland fire suppression course was extremely well received by several Indonesian agencies, and a total of about 45 professional foresters from throughout Indonesia were taught basic and intermediate fire suppression skills (Cougill 1989). As part of the ongoing training, six Indonesians, representing three agencies, arrived in Region 8 on October 13, 1989, for 3 weeks of intensive on-the-ground fire training. They participated in the North Carolina Annual Fire School and Field Problem; visited the areas damaged by Hurricane Hugo in South Carolina; and worked on prescribed burns in Florida, where they also visited the Everglades and Big Cyprus National Parks to study initial attack in swamp and tropical forestry environments.

Aerial Suppression Expertise Shared with China

Fred Fuchs, aerial suppression specialist and assistant director of Aviation Management, was part of the International Bank for Reconstruction and Development (World Bank) team to assist the People's Republic of China in the preparation and financing of a forest fire protection and rehabilitation project for the Daxinganling Forest Area in the most northerly parts of Heilongjiang Province and the Inner Mongolia Autonomous Region. Daxinganling was the scene of a huge fire burning 3,286,385 acres (1.3 million ha) in May 1987. The team evaluated the area firefighting capability, developed program objectives, and estimated the scope of investment required to reduce fire losses with the Republic's officials (Fuchs 1988). ■

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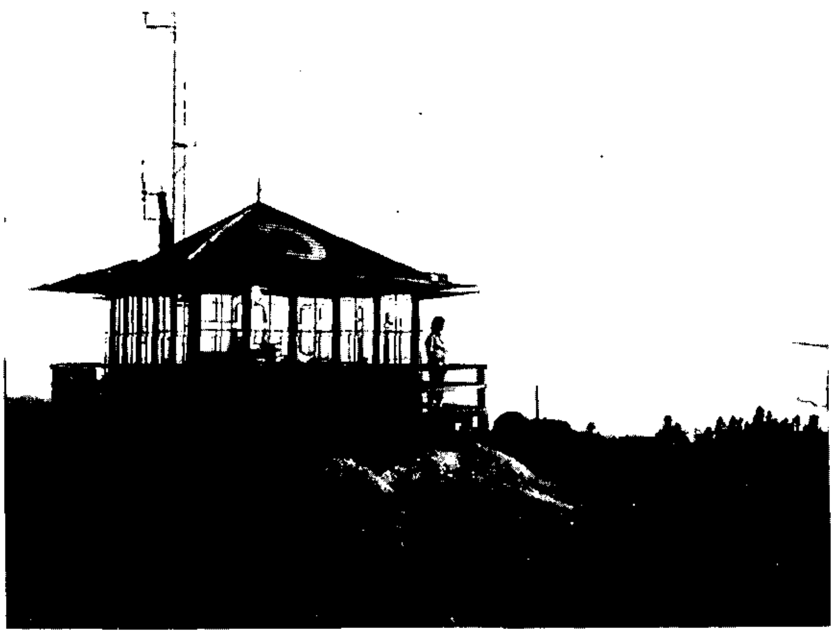

Devils Head Fire Tower, rebuilt in 1952.

Devils Head Fire Tower: Going Strong

Helen Dowe, one of the first women in the United States to become a fire lookout, no longer climbs the steep steps or scans the landscape at Devils Head Fire Tower in Pike and San Isabel National Forest, as photographs in "The Way We Were" photostory in Fire Management Notes' anniversary issue (50(1) pictured her. But spotting for fire continues at Devils Head, located in the South Platte Ranger District of the Pike and San Isabel National Forest. Lookouts Bill Ellis and his daughter Dolly are the ones now making their way up the steps to walk the catwalk and use the Osborne Fire Finder to fix the location of some distant puff of smoke. In fact, Bill Ellis, known for the precision of his fire reporting, has worked at the tower on and off for 23 of the 78 years Devils Head has been in existence.

The Denver Post in its July 9, 1989, story about Devils Head and the work of the Ellises reported that from the fire tower they "keep their eye peeled for smoke across nearly 20,000 square miles of the Colorado Rockies." It is one of two fire towers in Colorado still regularly manned, and because it is located in what is known as a "fire belt," it will probably be used for active fire watching for some time. District Ranger Ed Ryberg reports that the 1⅜-mile trail leading up to Devils Head was designated as a National Recreation Trail in 1980. Through a partnership established between the Forest Service, the Business and Professional Women's Organization, and the Rampart Range Motorcycle Management Committee, the trail is being reconstructed and interpretive trail signs installed this summer. "The trail receives about 14,000 visitors annually," Ranger Ryberg notes. ■

Photograph: Courtesy of Jerry Cleveland, *The Denver Post*

Update of the BEHAVE Fire Behavior Prediction System

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The BEHAVE fire behavior prediction and fuel modeling system has been expanded to include additional prediction capabilities. In this paper we summarize the changes and tell where to obtain the programs and documentation. We also describe some applications of the system and discuss the past and the future of BEHAVE.

BEHAVE System Design

A diagram of the BEHAVE system design is shown in figure 1. There are two subsystems, FUEL and BURN. The FUEL subsystem is made up of the NEWMDL and TSTMDL programs; the BURN subsystem, of the FIRE1 and FIRE2 programs.

The FUEL subsystem is used to develop and test fuel models: NEWMDL, to set the initial values for the fuel model parameters; then TSTMDL, to examine fire behavior predictions using the fuel model with a variety of environmental conditions.

The BURN subsystem is the operational fire behavior prediction part of BEHAVE. Figure 1 shows that the programs, FIRE1 and FIRE2, consist of various fire behavior prediction modules. There are two programs rather than one in order to limit program size.

Summary of Changes

The update to BEHAVE consists of additions to the FIRE1 program and an all new FIRE2 program. The only change to the NEWMDL and TSTMDL programs is the addition of a metric unit option.

The following capabilities have been added:

- Crown scorch height can be calculated from flame length, ambient temperature, and windspeed. Flame length can be either a calculated value or a direct entry.
- Percentage or probability of tree mortality can be calculated from scorch height and a description of the tree. Scorch height can be either a calculated value or a direct entry.
- Spotting distance from a wind-driven surface fire can be calculated from flame length, windspeed, and a description of the terrain. Flame length can be either a calculated value or a direct entry.

Continued use of BEHAVE is expected because of the need for fire managers to back up their decisions with quantitative information.

- Southern U.S. tree species can now be used in the calculation of spotting distance from torching trees.
- Calculated spread distance or spotting distance can be translated to map distance.
- Terrain slope can be calculated from topographic map measurements.
- Probability of ignition can be calculated from fine dead fuel moisture, ambient air temperature, and shading of fuels. In addition, probability of ignition is calculated automatically as part of the fine dead fuel moisture module.
- The fine dead fuel moisture model that was previously available in SITE is now also a module on its own. Calculating moisture content for ranges of values is now an option, and hourly moisture values can be displayed as a graph.
- Relative humidity can be calculated from wet and dry bulb temperatures and elevation.
- User comments can be written to log files.
- Either English or metric units can be used. The choice of unit can be made at any time.
- Slope can be specified as either percent or degrees.
- The status of mode keywords and names of the log file and fuel model file can be displayed.
- The version number of the program is printed with all output.

Documentation

It is not difficult to run the BEHAVE programs. But running the programs is not the same thing as using them properly. It is the responsibility of the user to supply valid values for input and to interpret the predictions properly. The BEHAVE papers are primarily devoted to explanation of the models that are used to make the predictions and to proper application of the system.

Three papers on the BEHAVE system are available. Burgan and Rothermel (1984) describe the FUEL subsystem. Andrews (1986) covers

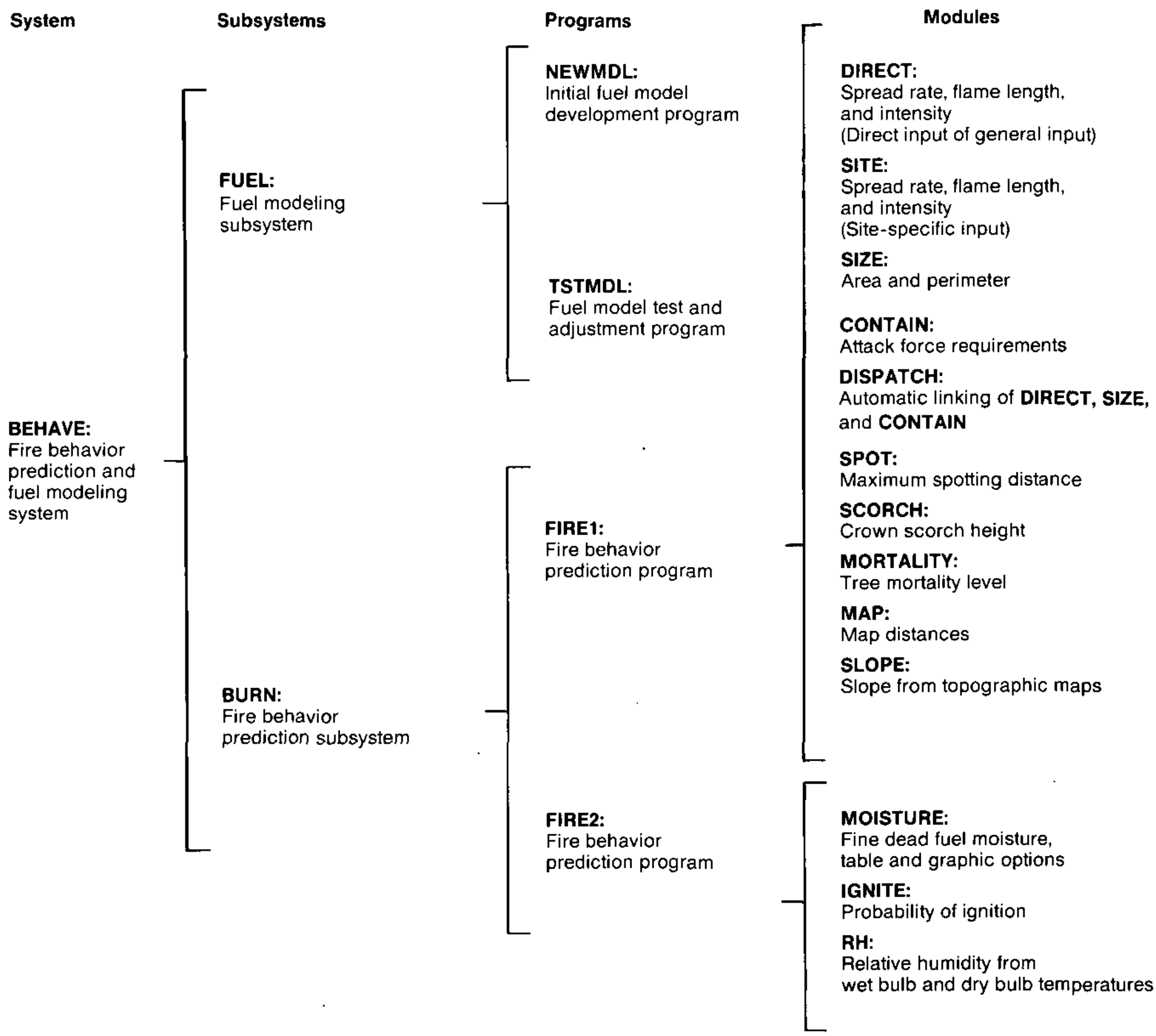

Figure 1—*Subsystems, programs, and modules of the BEHAVE system. The update includes the new FIRE2 program and additions to the FIRE1 program.*

the initial release of the FIRE1 program in part 1 of the BURN manual. Additions to the FIRE1 program and the new FIRE2 program are described by Andrews and Chase (1989) in part 2 of the BURN manual. These papers are available through the Publications Management System, Boise Interagency Fire Center Warehouse, (Attn: Supply), 3905 Vista Avenue, Boise, ID 83705; telephone: (208) 389–2542 or FTS 554–2542.

Related publications are Rothermel's (1983) "How To Predict the

Spread and Intensity of Forest and Range Fires'' and Burgan's (1987) ''Concepts and Interpreted Examples in Advanced Fuel Modeling.''

Programs

The BEHAVE programs were written and documented by research personnel at the Intermountain Fire Sciences Laboratory in Missoula, MT. Because it is now an operational tool, the BEHAVE support function has been transferred to Fire and Aviation Management in the Washington Office: Fire and Aviation Management, USDA Forest Service, P.O. Box 96090, U.S. Department of Agriculture, Washington, DC; telephone: (202) 453–9503 or FTS 453–9503.

Forest Service users received the update (version 4.0) through normal Data General procedures. Personal computer users can obtain the programs on floppy disks from Forest Resources Systems Institute (FORS), 122 Helton Court, Florence, AL 35630; telephone: (205) 767–0250.

The BEHAVE programs are written in standard Fortran and have been successfully transferred to a variety of computers.

Applications of BEHAVE

BEHAVE was first used on a wildfire in 1984. The North Hills Fire burned into the Gates of the Mountains Wilderness and threatened the outskirts of Helena, MT. The fire was visible—it could be seen from the capital—and the fire camp was visited by the Governor. Managers were faced with making a decision on the level of suppression action to take in the wilderness. Due to the difficulty and expense of carrying out an intense suppression operation in the wilderness and because the fire was not expected to reach the other side of the wilderness and further threaten people and property, a strategy of confinement was preferred. Predictions from BEHAVE were used by Dave Poncin, Incident Commander, to support and explain his position to his supervisors. The fire behaved as predicted. Poncin estimated that over $750,000 was saved by the decision to use modified suppression action in the wilderness.

This spectacular introduction of BEHAVE was written up in a press release that led to some interesting articles in the popular press. For example, one article had the subtitle ''Scientists Use BEHAVE Software to Extinguish Forest Fires.'' No, we don't claim that BEHAVE can do everything. But when it is used by educated, innovative fire managers, it can be a worthwhile ''tool.''

The following are some selected examples of applications of the BEHAVE system.

- ''A Field Guide for Appropriate Suppression Response,'' prepared by the Mt. Hood National Forest, includes BEHAVE tables for rate of spread, flame length, and required line-building rate for various possible conditions.
- Sequoia and Kings Canyon National Park is currently using BEHAVE to make decisions on whether prescribed burning is necessary. Fuel is sampled and a custom fuel model is developed for the area under consideration. Based on the behavior predicted for a prescribed fire in that fuel type, the area is classified as either a natural fire zone or as an area that should be burned to reduce fuel accumulation and therefore fire hazard. Significant savings have been realized because of reduced need for prescribed fire in the park. In addition, custom fuel models are being developed for high elevation areas in the park so that the behavior of prescribed natural fires can be better predicted.
- The calculation of maximum spotting distance from torching trees was used to determine whether a spot fire that was detected in the vicinity of an ongoing prescribed natural fire could have been caused by an ember from the main fire or whether it was more likely to have been caused by a lightning strike, indicating treatment as a new ignition and a separate fire.
- The model that calculates the moisture content of fine dead fuel was used in Yellowstone National Park during the fires of 1988. Calculations were done in early September to estimate probable fuel moisture and the damping effect on the fires based on expected rains in mid-September.
- BEHAVE has been integrated into the Bureau of Land Management's Initial Attack Management System (IAMS). Information on the fuel type and weather conditions is automatically retrieved for a new fire start, and initial estimates are made for potential fire behavior, including spread rate, intensity, and size. The user is then allowed access to the FIRE1 program to do

additional calculation of potential fire behavior.

- BEHAVE has been used worldwide for some time. This is the case even though the initial release of BEHAVE offered only English units. The current version includes the option of using either metric or English units. The user has the flexibility of making the conversion at any time. It is possible, for example, to enter input in English and display the results in metric. The real indication of interest in using BEHAVE outside of the United States is that the user interface of the code has been translated into two other languages. The University of Science and Technology of China translated BEHAVE into Chinese. A Spanish version of the FIRE1 and FIRE2 programs will be used as the basis of the fire behavior prediction portion of an international course. The course will be attended by people from 20 to 40 Spanish-speaking countries.

Continued use of BEHAVE is expected because of the need for fire managers to back their decisions with quantitative information.

BEHAVE: Past and Future

The BEHAVE system was designed for use by fire managers rather than computer specialists. When we taught the first BEHAVE courses in 1984, we encountered many people who had never touched a computer terminal. It has been gratifying to see people become comfortable using the programs. Computers are now a common and vital part of the work environment.

The programs were originally written to accommodate people who used slow hard-copy terminals connected to remote mainframe computers. We offered the TERSE option so that people wouldn't have to wait for the computer to type a few additional words. We didn't have the option of using windows, cursor control, color, and other bells-and-whistles that we might have utilized if we were designing the system today.

Nevertheless, we have no plans to repackage BEHAVE. It serves its purpose in its present form. And people are comfortable with it. As researchers, our time is better spent developing improved fire behavior prediction models. The next generation fire behavior/fire danger rating systems will incorporate advances in research as well as use state-of-the-art technology. Future systems will be more than just a flashy version of the current ones (Rothermel and Andrews 1987).

The only change that is planned for BEHAVE is the addition of the RXWINDOW program to the BURN subsystem. It is designed for prescribed fire planning, reversing the calculations that are in the DIRECT, SCORCH, and MORTALITY modules that are in the FIRE1 program. The fire manager specifies acceptable fire behavior, and RXWINDOW gives the associated environmental conditions. ■

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Florida's Fire Reduction Initiative

James B. Whitson

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Has the Florida Division of Forestry found a unique and innovative way to reduce the number of human-caused wildland fires in our State? Not really. The Division can report, however, that it has a new direction and resolve in tackling this problem.

Florida's population growth has been phenomenal over the past 20 years, and in recent years it is reported that a thousand new residents move to the State each day. This growth has increased the pressures on our infrastructure, including an additional burden on wildland firefighting resources. A major fire-hazard crisis has occurred in our wildland-urban interface. Wildland fire managers have always known that population growth into the wildlands was a dangerous trend, but our worst fears were realized in 1985 with the destruction and damage of over 600 structures.

An active fire prevention program has always been in place in Florida, and for the past 20 years the trend in human-caused fire has been slightly downward (fig. 1). This indicates that we have been doing something right. Still, our average of about 6,000 human-caused fires each year is too many.

Reinvigorated Fire Prevention Effort

In mid-1988 our newly appointed Director, Harold K. Mikell, challenged field managers to begin a more intensive prevention effort in their units. In January 1989, the Fire Control Bureau, in conjunction with the Forest Education Bureau, launched a Statewide campaign known as the Florida Fire Reduction Initiative.

A State action plan was developed and approved with its main thrust toward tackling careless human-caused fire.

In essence, the Florida Fire Reduction Initiative is an umbrella over several related programs, such as traditional fire prevention, wildland-urban interface, law enforcement, and landowner services of the Division of Florida Forestry, and the Arson Alert Association. All of these programs are now coordinated through the initiative.

To launch the initiative, an interagency committee has been formed at the State level. Its primary mission is to filter activities in field units to ensure cost-effective programs and to eliminate duplication in development efforts. Each field unit has its own interagency group designed to implement priority programs within each county.

A State action plan was developed and approved with its main thrust toward tackling careless human-caused fire. Although Florida has two leading causes (fig. 2), the State committee felt that for one of the causes—careless debris-burning—significant progress could be made to reduce the number of fires. Incendiarism is also a major problem but will require an intensive law enforcement effort beyond the capability of our normal prevention forces.

Seed Money and Cooperation

In the first part of fiscal year 1989, the Division of Forestry was fortunate enough to be awarded a small grant from the USDA Forest Service targeted toward education within the wildland-urban interface. Quickly we realized that the wildland-urban prevention problem could not be treated separately from other prevention problems occurring around the State; therefore, these funds were used in a variety of ways within the initiative. While the grant was small, it did, however, serve as a catalyst to generate a renewed interest in wildland fire prevention Statewide.

Several significant projects are underway in Florida both at the local level and Statewide. A significant project funded by our Forest Service grant was the development and implementation of Volunteers in Prevention (VIP) program. This program is designed to involve local citizens in protecting their neighborhoods. We feel that the VIP program has potential to significantly reduce careless wildland fires.

Another major effort is to develop and deploy a fire prevention task force within the State. The task force will be composed of a leader, two law enforcement officers, an information officer, and a pilot who has the use of an airplane. The concept is to deploy this task force into any region of the State experiencing a buildup of human-caused fire. They will coordinate a saturated effort of both law enforcement and media. The aircraft will be used to carry representatives from law enforcement and the media and to spot illegal burnings. We have high hopes for this project.

Also on the drawing board is a Red Flag Warning System. Several systems from around the Nation have

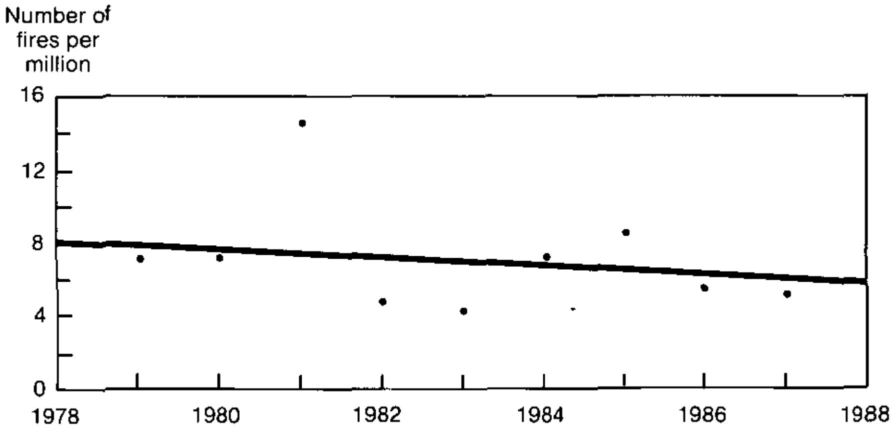


Figure 1—*Number of human-caused wildland fires over a 10-year period in Florida.*

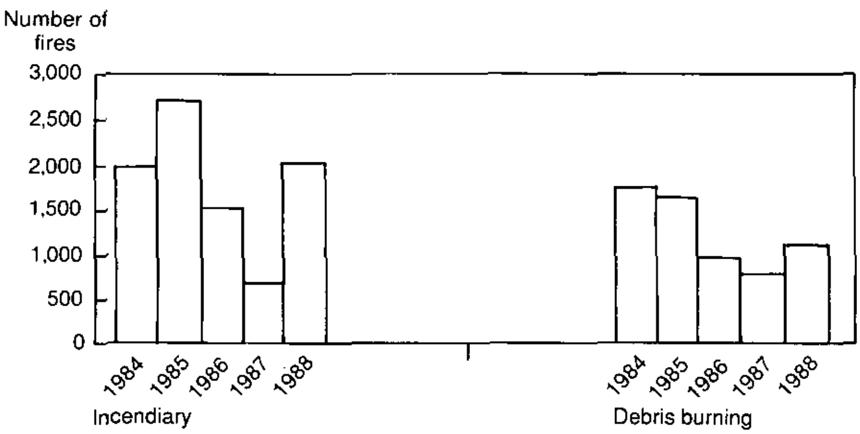
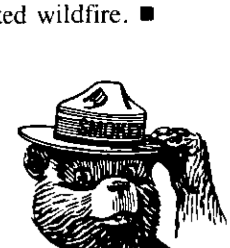


Figure 2—*Number of wildfires from leading causes in Florida from 1984 to 1988.*

been researched, and the best parts of those will be designed into a Florida system. Plans are to introduce this program with a massive campaign during fiscal year 1990.

An initiative such as this cannot be successfully conducted by a single agency, and we would not have attempted it without the support of all the emergency services in Florida. Fire departments that respond to wildland fire within the interface have as great a stake in this project as the Division of Forestry. Working together, we can eliminate many of these human-caused fires. Together, we can improve our environment and make the wildland safe from unwanted wildfire. ■



Subscription Fire Departments and FEPP

Fire departments raise and supplement their revenue in a variety of ways, from pancake suppers, raffles, bingo, and carnivals to fund drives. Some fire departments are not publicly funded but rely on fees paid by property owners for property protection. Those unwilling or unable to pay the fee are sometimes left unprotected. Subscription fire departments have been known to put out a fire for a nonmember and then bill them. On rare occasions, they have stood and watched the property of nonmembers burn, because they were responsible for protecting the property of only paid members. In some States, subscription fire departments have been successfully sued by irate homeowners. Subscription fire departments are also under pressure within some States to protect the property of all residents when they accept State or local funds or tax benefits.

Subscription fire departments have left us with a dilemma when they apply for Rural Community Fire Protection grants or the loan of Federal Excess Personal Property (FEPP). On the one hand, in some States, they are within their rights to withhold their services to nonmembers, but on the other hand, Federal property and Federal funds are for the benefit of all citizens. Fire departments accepting FEPP equipment and Federal grants should be strongly encouraged to protect the entire community in a nondiscriminatory manner. This should work to the benefit of all—in reduced fire insurance premiums and good community relations. Our programs are subject to criticism if our equipment is on restricted service. ■

Francis R. Russ, *property management specialist, USDA Forest Service, Fire and Aviation Management, Washington, DC*

Fire Policy in Developing National Parks of Sub-Saharan Africa

Richard G. Ruggiero

Graduate student, Rutgers University, Cook College, Department of Horticulture and Forestry, Wildlife Ecology Program, New Brunswick, NJ[1]

Introduction

Fire has been a factor in the formation and maintenance of African habitats for centuries (Lamprey 1974). Early humans possibly first used fire for heating, then later for cooking meat and as a tool in gathering honey (Lasan 1979). Although it is agreed that naturally occurring fire played a role in the formation and maintenance of African savannas, human use of fire probably extended the effects. It is speculated that fire was used as an aid to hunting and to clear land for cultivation (Lasan 1979). Early pastoralists used fire to clear away accumulated low-quality dried grass that may be replaced by new, more nutritious growth. Fire is now ubiquitous in Africa outside of permanently moist areas, and grasses covering vast areas are burned every year.

Most national parks and nature reserves in West and Westcentral Africa are still in an early stage of development and management (Spinage 1979). Many have poorly defined or unstated management strategies and fire policies. Under the best of circumstances, an ecologist would carry out a long-term series of experiments to determine the effects of various grass-burning regimes on each vegetation and soil type. Experimental plots can be set up to test the effects of a total ban on burning and prescribed fires set at various times of the day and various times of the dry season. The results may then be applied to serve the conservation aims of each area. However, these experiments are time-consuming, demand good experimental technique, and take many years to yield useful information. In addition to variations caused by the nature of the vegetation, soil conditions and local weather patterns must also be taken into consideration. The number and longevity of experiments necessary to account for these variables are usually beyond the reach of many park systems in developing countries. Therefore, in the absence of well-interpreted data from experimental plots, some general guidelines may be useful until more site-specific information becomes available.

The scientific use of prescribed burning in the fire-prone African savannas is a challenge facing many managers of conservation areas.

Fire as a Management Tool

The scientific use of prescribed burning in the fire-prone African savannas is a challenge facing many managers of conservation areas (van Wilgen and Wills 1988). Properly wielded, fire is probably the most powerful management tool in the African savannas. Although posing great potential for destruction if misapplied, a well-designed program can serve several management goals. Because many national parks and wildlife reserves are managed with consideration for tourism or big game hunting, fire can be used to remove dry grass and to reduce woody vegetation so that visibility is enhanced. Programs to control tse-tse flies by reducing numbers of adult flies and disturbing the microclimate necessary for successful reproduction frequently employ fire. Ticks and other parasites may also be controlled in this manner (Egunjobi 1979). Fire is sometimes applied to retard colonizing woody plants and maintain a subclimax sere. Provided that sufficient soil moisture is present, the thermal shock of passing flames may cause a precocious regrowth of perennial grasses. This "green-grass flush" is valuable to grazers because high-quality forage is usually very scarce during the dry season (fig. 1). This technique may raise the carrying capacity of grazing ungulates and may suit game ranches and hunting preserves.

Many national parks are mandated to conserve biodiversity. Implicit in such a goal is the need to conserve habitat diversity (fig. 2). Here, a burning plan is called for that preserves fire-sensitive vegetation types such as dry forests while maintaining productive grasslands in other areas and allowing succession to continue in others. However, some ecologists hold the view that soil and water conservation needs take precedence over some relatively short-term, local effects such as inducing a green-grass flush for a group of ungulates, and fire policy should therefore be built around these considerations.

Much of Africa's savannas are derived and maintained by fire (Glover 1968). As a result of the frequency of grass fires in most African

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savannas, many vegetative communities consist almost exclusively of fire-tolerant plants. The timing and frequency of grass fires greatly affect the structure and composition of vegetation as well as other environmental conditions. Some of the expected effects of the timing of dry season fires are summarized below.

Early Fire Treatments

Fire regimes are usually described as early or late. Some authors refer to early fires as cool fires and late fires as hot (Rogers 1979). An early fire is set at the beginning of the dry season as soon as the grass is dry enough to allow propagation of the fire. Late burns are set at the end of the dry season just before the return of the seasonal rains. The effects of these two extremes differ considerably and may be applied to serve different aims, which are briefly discussed below.

In general, early fires produce flames that burn close to the ground at temperatures less than 300 °C. Effects are minimal, below 0.8 inch (2 cm) from the surface (Rogers 1979). Treetops, dense shrubs, and some of the greener, shade-tolerant grasses may be relatively unaffected. Fire-intolerant trees and shrubs that grow atop termite mounds are also minimally affected by most early fires. Deadwood is slowly consumed by early fires, and portions of logs are incompletely burned. Sometimes only the heartwood burns out of a log leaving a hollow cylinder which may serve as shelter for a variety of animals. Because early fires are relatively cool, many seeds lying on the

Figure 1—*A herd of Buffon's kob (*Kobus kob*) on a floodplain in the Gounda-St. Floris National Park, Central African Republic. The nutritious grass regrowth was stimulated by an early dry season fire set 10 days earlier.*

Figure 2—*Some large predators such as lions (*Panthera leo*) rely on the cover of unburned grass while stalking prey.*

ground survive the passage of the flames and will germinate with the first rains (Afolayan and Ajayi 1980). Watercourses, animal trails (particularly those of elephants), changes in wind direction, and heavy dewfalls may extinguish an early fire, leaving some areas unburned.

Late Fire Treatments

Late fires are considerably hotter and faster moving than earlier burns. They frequently attain 600 °C and move rapidly at 1.1 to 2.2 yards (1 to 2 m) above the ground. The effects of their high temperature can reach downward as much as 2 inches (5 cm) below the surface (Rogers 1979). Trees are often damaged or killed and even the tops may sustain extensive damage. Leaves and flowers are sometimes burned off, and birds' nests may catch fire when tall flames pass nearby. Deadwood is rapidly consumed and little is left behind as wildlife shelter or food for termites. Small barriers are jumped, and fires may burn against even relatively strong winds. Tree seedlings are most vulnerable to hot fires; therefore, pastoralists favor late fires to remove woody vegetation in favor of grasses. Irreconcilable differences in the interests of pastoralists and foresters have been noted in the literature and are reflected in the preference for timing and frequency of fires (Egunjobi 1979).

Repeated late fires contribute to surface soil compactness and may decrease grazing value (Trapnell et al. 1976). There appears to be much variation from one area to another, and this technique should probably be limited to areas for which good local data on fire's effect on each vegetation and soil type are available.

To Burn or Not To Burn

The prohibition of fires may be necessary in certain areas. For example, dry forests and gallery forests contain fire-sensitive plant communities. They may sustain extensive damage from even one incursion of fire and should be protected from inadvertent burning. Areas around buildings must be protected, and some erosion-prone areas benefit from a cover of dried grass. Soil erosion from burned areas is a great problem throughout the Sahel and other parts of West and Central Africa. The faster runoff from burned areas may reduce infiltration of water into the soil and aquifers. Much of the turbidity of rivers and streams is attributed to this phenomenon. Periodically, drought-stressed or degraded areas may benefit from leaving larger amounts of dried grass and forest litter unburned, thereby reducing insolation on the soil surface and decreasing evaporation of soil moisture. The danger involved with this technique is that an accumulation of combustible material poses a tremendous threat to vegetation and soils if grasses are ignited under the extremely arid conditions of the late dry season.

Experience has shown that poachers and illegal herders often are the source of dangerous late dry season fires (Ruggiero 1989). Managers cannot assure that late season fires will not be started by poachers or even noncultural sources such as lightning. In many areas, this eliminates the possibility of a "no-burn" policy as a way of lessening the drought's effects on soils and vegetation. Poachers often set fires in remote areas, and it would not be surprising to learn that in many large national parks, greater areas are burned by poachers than by park management. Illegally set fires are commonly seen throughout the dry season in most places, and some of these fires would serve the conservation aims of isolated late burns provided that they were relatively infrequent and were limited in extent by prescribed early season fires (Ruggiero 1989).

Some areas can be protected by firebreaks, but this approach for the most part is limited in its applicability. An alternative is to burn as early as possible in or around fire-sensitive areas. Early fires are less destructive of woody vegetation than late season burns. If early season fires are ignited before the grasses are completely dry, on mornings with a heavy dewfall or late in the afternoon after the day's winds have diminished, the results are usually a "mosaic-effect," which is a good compromise between the complete removal of dried grass and no burning at all. In the event that poachers set destructive late season fires, another benefit of a burn resulting in a mosaic-effect is the reduction of contiguous unburned areas and consequently potential fire hazard. The mosaic-effect that results from a proper early burn provides islands of unburned grass that serve as refuge for certain cryptic species and may

Figure 3—*A properly burned riverine grassland yields a mosaic of clearings and grassy areas that are highly productive and offer wildlife cover.*

be used by elephants for resting and a source of hay (fig. 3) (Ruggiero 1989).

There are, however, three potential disadvantages to early burning. Burning a large area over a short period of time demands a large labor force and a considerable amount of transport, two items in very short supply in most developing national parks. Grass burning is a time-consuming, dirty, and sometimes hazardous job that requires an experienced team. Allotment of sufficient personnel and equipment to complete the burn in a relatively short period of time, perhaps about one month, may temporarily divert antipoaching, maintenance, and construction resources at a critical time of year.

A second practical drawback is that if an area is burned too early, too much grass will remain. This would defeat the purpose of the burning regime. Burning too early may also result in damage to perennial grasses that have not yet relocated their resources to below ground parts. This may kill the perennial grass and result in the problems associated with soil erosion from the bare spot. In addition, patches once covered by perennial grasses may be colonized by less palatable annual species.

It can be argued that management for habitat diversity calls for some late burning in order to remove most or all woody vegetation and produce the open rangeland preferred by some species. Late burning, when the aerial parts of perennial grasses are dormant, reduces shrubs that might compete with grasses (Afolayan and Ajayi 1980). Under some conditions, more damage is done to perennial grasses when the flush that follows the burn is grazed, and late burning may resuscitate the disappearing perennial grasses (Afolayan and Ajayi 1980).

A generalized burning guide, modified from Barber et al. (1979) and Koster (1977), for conservation areas in West and Central Africa is given below:

- Do not burn unless it is necessary to perform a specific task, for example, preparation of roads for game viewing or regrading, and provocation of grass regrowth as food for ungulates. Uncontrolled or poorly timed fires do not benefit soil, water, vegetation, and the wildlife that depend on these resources.
- Give special consideration to each vegetation type and base a specific burning policy on information from the scientific literature and data gathered from experimental plots set up in the park.
- Because much of the park burns uncontrollably, address the problem of illegal fires through antipoaching programs and efforts aimed at the minimization of human interference in the park. As complete exclusion of illicit burning is outside the realm of practicality, attempt to limit the extent of these burns by patrolling areas that are traditionally burned by poachers and by carrying out preventive fires early enough in the dry season to reduce the amount of combustible material that may later be subject to fires.
- As part of management's burning regime, include provisions for leaving some unburned areas in

each vegetation type throughout the park.

- Carry out burning as soon as possible at the beginning of the dry season, as road maintenance and game viewing depend on this. Early burning is, in general, a necessity in many national parks and hunting reserves. Because it may be advantageous to do so, attempt a degree of rotation in the burning pattern in order to allow for the fact that while burning is beneficial to some species, it is harmful to others.
- Give particular care to areas near watercourses and places that are prone to soil erosion, overgrazing, or the effects of drought. In addition, wooded areas that experience significant levels of elephant damage may benefit from a hiatus of 2 or 3 years in the burning regime. This may encourage the growth of seedlings and small trees as well as the production of branches and leaves near the ground where they are available to browsing elephants and other folivores. ■

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Civil Defense FEPP

The Defense Civil Preparedness Agency (DCPA), formerly an agency of the Department of Defense, was authorized to place Federal Excess Personal Property (FEPP) in fire departments' radiation decontamination units. This use was compatible with Forest Service fire protection activities because their vehicles also carried water and pumping equipment.

In the mid-1970's, DCPA was transferred to the Federal Emergency Management Agency and lost its authority to acquire and loan FEPP. In 1979, DCPA received congressional approval to turn over ownership of FEPP to its holders. Much of this equipment, mostly loaned vehicles, is still in fire department use. Some, however, is not operational and sits as an unsightly reminder of a past program.

Some State forestry agencies have assisted fire departments in getting the vehicles painted and in obtaining clear title to the vehicles DCPA gave the departments. This is encouraged because it benefits the fire departments by promoting use and upkeep of the vehicles.

Because of the DCPA program, some fire departments have mistakenly assumed that they get title to FEPP under our program. This misunderstanding has caused a problem in some States. The frequency with which some rural fire departments change chiefs and other fire personnel requires that our vehicles be marked as Federal property and that someone periodically monitor their use. It is also important that there be a current cooperative agreement with the fire department. These kinds of precautions can help prevent misunderstandings with on-loan Forest Service FEPP. ■

Francis R. Russ, *property management specialist, USDA Forest Service, Fire and Aviation Management, Washington, DC*

Subject Index—Volume 50

Fire Behavior

Fuels

General Fire Management

Personnel

Presuppression

Prevention

Suppression

Training

If you live in or adjacent to a wooded area..

Your home could be in danger from wildfire this winter and spring!

The tangled masses of trees left by Hugo will allow fires to spread rapidly and burn with great intensity, and the downed timber will severely restrict the maneuverability and efficiency of our firefighting equipment.

Firefighting agencies in the area will do everything possible to protect life and property, but they will not be able to do the job alone. *Residents are advised to take the following precautions, beginning immediately:*

- **Avoid** any outdoor burning and urge your neighbors to do the same.
- **Remove** all flammable material within 50 feet of your home and other structures.This includes *storm debris, pine straw mulch, and flammable shrubs.*
- **Remove** *flammable material (pine straw, leaves, etc.) from your roof and* gutters. Keep your roof clear.
- **Report** any smoke or woodland fire immediately to the nearest fire tower. Look up the number now and keep it by the telephone.
- **Do** not set "backfires" around your residence without first checking with fire officials. Your backfire could become a deathtrap for firefighters caught between it and the wildfire.
- **Plan** escape routes in case evacuation becomes necessary, and locate *safety zones (plowed fields, ponds, etc.) for use if escape is impossible.*
- **Evacuate** immediately if ordered by fire officials or if you feel threatened by fire. *DON'T WAIT UNTIL YOU SEE THE FLAMES.*
- **Contact** your county Emergency Office NOW (see below), if you do not normally have transportation, or if your children are frequently at home alone. Should evacuation become necessary, this information will help officials get you to safety.

Again, please avoid outdoor burning for the next 12 months
... its just not worth the risk.

GIMME

12

GIMME 12 Fire Prevention Campaign

The fire safety letter reproduced on this page was sent by the South Carolina Forestry Commission to 300,000 postal customers on the Hurricane Hugo-damaged area in South Carolina. It was part of an intensive campaign to inform people about fire danger in the area and to modify their behavior in the use of fire out-of-doors with this simple message: "Avoid outdoor burning for 12 months...GIMME 12 months of fire safety.

On a following page is another component of the Commission's campaign: Their advice on outdoor burning, printed on 4-by 8-inch card stock, with telephone numbers for each Commission tower in nine counties.

Author Index—Volume 50

If You Are Burning Out-of-doors,

Please read this —

Outdoor burning can be very dangerous this year. We encourage you to find other ways to dispose of your debris, but if you <u>must</u> burn:

1. **Notify** the S.C. Forestry Commission before starting the fire as required by state law. They can explain your legal responsibilities and provide up-to-date weather information.
2. **Keep** debris piles small for maximum control; feed additional material as the pile burns down.
3. **Rake** or plow a wide safety strip around the burning site to prevent your fire from spreading. No flammable material may be exposed in the safety strip.
4. **Burn** brush on damp days or during a light rain. When the debris is dry, cover it with plastic and wait for a day when everything else is wet.
5. **Keep** a garden hose or other water supply at hand while burning. Make sure you have enough help and enough tools to keep the fire contained.
6. **Stay** with your fire at all times. Don't leave until you're **<u>sure</u> it is dead out!**
7. **Call** for help immediately if your fire starts getting out of hand.

S.C.Forestry Commission US Forest Service

S.C.Forestry Commission towers to call for Notification, by County.

<u>Camden District</u>

Kershaw County

Camden Tower	432-2313
Liberty Tower, Liberty Hill-	273-8445
Buffalo Tower, Kershaw-	475-4172
Westville Tower, Kershaw-	475-4122
Blaney Tower, Elgin-	438-3975
Cassett Tower, Cassett-	432-8291
Cross Tower, Cross-	753-2508

Clarendon County

Foreston Tower, Manning-	473-2385
Summerton Tower, Summerton-	473-2674
New Zion Tower, New Zion-	659-2837

Lancaster County

Primus Tower, Health Springs-	286-8080

Lee County

Bishopville Tower, Bishopville-	428-3830
Atkins Tower, Lynchburg-	437-2596

Williamsburg County

Cooper Tower, Lake City-	382-3339
Earle Tower, Andrews-	221-5718
Lane Tower, Salters-	387-5654
Cook Tower, Nesmith-	382-2729

Sumter County

Catchall Tower, Dalzell-	499-4545
Rosemary Tower, Wedgefield-	494-8168
Black River Tower Mayesville-	495-2682

<u>Kingstree district</u>

Berkeley County

Bonneau Tower, Bonneau-	761-8580
Pineville Tower, Pineville-	351-4314
OakleyTower, MoncksCorner-	761-2745

<u>Walterboro District</u>

Charleston County

Johns Island Tower, Johns Island-	559-9830
AdamsRun Tower, Adams Run-	899-6311
Mc'ville Tower, McClellanville-	887-3353

Dorchester County

Ridgeville Tower, Ridgeville-	873-4330
Summerville Tower, Summerville-	873-3372
St. George Tower, St. George-	563-3722

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