FIRE CONTROL NOTES

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U.S. DEPARTMENT OF AGRICULTURE • FOREST SERVICE

FIRE CONTROL NOTES

An international quarterly periodical devoted to forest fire control

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The Cover:

How accurately can a smoke jumper jump?

This is a Forest Service smokejumper descending toward a forest fire in Montana.

Note steering slots at back of parachute canopy. Air escaping from the slots and three lobes or "tails" gives the jumper an 8 m.p.h. forward speed. He can make a 360° turn in about 8 seconds by pulling down on one of the guidelines (see two dark-colored shroud lines). △

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What Are Forest Service Fire Control Needs In Weather Information

Merle S. Lowden

This article is the speech given by Merle S. Lowden at the Fire Weather Meteorologists Conference, Boise, Idaho, March 1971. Mr. Lowden retired as director of Fire Control, W.O., June 1971, after 37 years of service. His leadership and devotion to fire control is well known and his clear, objective approach to fire control needs is reflected in this speech.

I can remember quite well the very beginnings of the modern national Fire Weather program. It had its early start in a meeting of the two Chiefs of the Weather Bureau and the Forest Service. At that meeting it was decided such a program would be prepared jointly. I recall being at the "end of the line" at that time and being given the assignment to head the Forest Service side of the working group.

The early plan took hold. It was a rallying point for joint efforts and seemed to catch the attention of many people, including the Congress. Additional manning and other resources were made available, and the Fire Weather Service grew. Services greatly increased in many ways, and we in the Forest Service were pleased and encouraged. However, as appropriations slowed up and increases no longer materialized, we were disappointed and somewhat discouraged. Many of the fire weather people also seemed to reflect part of this discouragement.

Essentials

Although the plan has gone through many modifications and changes, its essentials are pretty must the same: It provides a special comprehensive forecasting service for fire weather, supplemented by strong research efforts. The vital provisions of the program are more needed and pressing today than ever before. The values we protect are greater, and our people have more "know how" and, therefore, more appreciation of the value of the technology supplied to them and how they can use it.

Today

Today many of us are concerned because the forecaster is less available to our work. Rumors persist that this situation may worsen. We may inflate our importance, but we feel putting out forest fires is a special business, and we think those who provide the weather information we need and the services we require are also a "special breed of cats." We need the availability of specialists who know our job and are able to confer with us in any locality at all times of the day and night—and all days of the week during the dangerous fire season. It isn't enough just to be able to talk to a weatherman: We need someone who has studied and knows fire behavior, has been on our fires, and has seen what we do. We need someone who can speak with knowledge and experience.

At several locations where we don't have fire weather forecasters, we need them. And we need more of them at those fire weather locations already manned. We also need more mobile units.

In order to better prepare for disasters and be able to detect indices of disaster situations before they occur, we need analysis of post-situations of fire weather. A specialized weatherman can help us greatly on this. We need the advice of this skilled person at our formal fire analysis, at our wintertime reviews and planning sessions, and for individual consultations. During the next year or so, we will be making a detailed analysis of our fire problem on every National Forest, and we will be preparing specific plans for fire facilities, personnel, and actions. We'll need an increasing amount of help from the fire weathermen during this period, and we're hoping these men will be available. More assignments of fire weathermen to slash disposal projects would be extremely helpful. You're going to hear more from us on service for such operations. A man right on the ground with a mobile unit would really do a job for us. And he'd learn a lot too.

What We Want

In preparing this paper we solicited our Regions and from them we got many fine ideas of how the Fire Weather Service can be more helpful to us. And I hasten to add my commendations to those I received from the field on the service you have provided over the years. Our people are especially appreciative of the wonderful service your men gave to us on the big fire "busts" in 1970 in the State of Washington during July and August and in California during September and October.

Service has been good from the mobile forecast units at other times too, but these three special situations provided a real test of how the system works. I understand some of the units were on their way to the "bad" areas before we really got into a total fire situation. This is what we really like—you saw your duty and did it well in advance of our requests. When the situation got exceptionally bad in Washington State, I believe you had the most mobile units on fires in one State at one time in the history of your organization, and the service was superb.

Men worked exceedingly long hours and far beyond the call of normal duty. Their help was extremely valuable. But, back to our needs.

I made a recent trip through most of our Western Regions and attended fire analyses in three Regions. At these analyses, and in conversations with many of our men, I learned how much they value the Fire Weather Service and what they want to know more about. For instance, folks in the Pacific Northwest Region found rather substantial differences in the way fires burned at different times and different occasions, even though most of the usual indicators of fire spread and intensity seemed to be the same. They'd like the help of one or more Fire Weather men to study these things for that particular fire area. I believe we need more of such analyses.

When Is a Condition Critical?

We also need some studies to determine when we're at the threshold of a critical condition. In California our folks would like the Fire Weather Service to tell the public about these critical conditions and tell them why they must be particularly careful. We warn the public about these conditions, but they may get tired of hearing from us. We believe some type of alarm over radio and TV by your folks might be helpful, especially before a "Santa Ana."

In our analysis of critical fire weather situations before and after they happen, we need a more uniform approach or method. Perhaps it should be a regular, automatic procedure for the Fire Weather Service to provide us with an analysis of what happened before and during a critical fire "bust," according to a jointly agreed-to format. We need more emphasis on special alerts for approaching critical situations so we can be better prepared. Fire Weather personnel must call these situations to the attention of our men in a stronger manner, and we must respond faster.

Standardization

We still run into the request for more standardized procedures between Fire Weather Stations and, particularly, between your Regions. I realize you may not be able to cure this inter-regional problem from within this one Region, but it is still a problem to our people. The distribution and filing of 10-day fire weather records seems to vary even within a region.

A uniform and better forecast system for lightning forecasts seems particularly necessary and was asked for by several of our Regions. Since the frequency-probability system is confusing to many people, they do not know how to use it in their risk evaluations. A system that rates intensity and coverage would help.

Better and more comprehensive lightning forecasts may require much more research. It is perplexing and downright discouraging to have a lightning forecast, like you've all heard repeatedly, of "50 percent likelihood of lightning for tonight and tomorrow." Then you get either no lightning or one of the worst storms ever to occur on the Forest!

Other Needs

New concerns of people and changing times cause new requirements in fire weather forecasting. The entire field of smoke regulation, particularly related to slash burning, has produced many new needs. Some have suggested a standard system of forecasting daily atmospheric conditions influencing smoke dispersion such as stability, upper air flow, and other pertinent information. Fire weather folks helped in developing smoke management procedures, but undoubtedly they can be improved. We need help in this continued development and in the information such development will require.

There is continued talk about fire weather forecast accuracy. Perhaps this is a "sacred cow" I should not mention, but I wonder if a uniform method of testing accuracy or a study of accuracy wouldn't help. Maybe such a system would reveal many things we could all do to help forecasts. Maybe such a study would give our men more faith in your forecasts and your men more confidence in what they predict. More faith on the part of our men should make them act more decisively. Stronger faith by both sides is badly needed.

How close are we to computer-produced forecasts for our fire weather? There seem to be many advantages to them, and we need not shy away from them, thinking a machine will replace a man. A machine must have someone to tell it what to do. Since presuppression systems use digital, fire-weather forecast input in some places, and we're going in that direction in other places, why shouldn't we be heading for digital forecasts from computers, looking to more automatic systems of the future?

It has been our desire for a long time to have reasonably priced, remote sensing equipment for Fire Weather Stations, and we've spent many dollars trying to get such a system. Other agencies are developing and working with such equipment. Wouldn't it be desirable if we had more coordination with more active Weather Service participation?

On many occasions I've pointed out the great payoff that could result from longer range forecasts. We could shift men and equipment between Regions and even from one side of the country to another. We could make our prevention program more flexible and more immediate to current needs. Our allotment of funds between areas could have greater applicability than at present. I believe we could actually save millions if we knew of critical situations accurately a week or two before they occur.

There are a number of routine procedures we need to improve through joint efforts. Some think forecasts are too long. This is a special problem where forecasts must be relayed by radio. For some locations, the period for teletyped transmission of forecasts is too short, but money may be the problem in this case.

Not Nit-Picking

I hope these suggestions on our needs haven't sounded too much like a wild dream or a laundry list of nit-picking items. We tried to develop it to be helpful, but we realize the constraints of time and funds. We know you want to do better, and we want to help.

You have our deep gratitude for all your help in the past. △

A modern national Fire Weather program must provide a "special comprehensive forecasting service for fire weather, supported by strong research efforts."

Thermal Imagery Helps Determine How To Fight Fire

Elbert Reed

First reported on August 17, 1970, the Pumpkin Creek Fire burned out-of-control for 6 days, destroying 4,500 acres of timber and grasslands. Thermal imagery was requested the day the fire was reported, and before the fire was put out, three agencies had flown nine infra-red detection missions.

Who Flew?

The U. S. Air Force flew two missions, one on August 18 and one the next day. The Forest Service fire scan aircraft arrived late on the afternoon of August 19 and flew missions from August 20 through August 23. The next missions were flown by the Bureau of Land Management fire scan aircraft using the Bendix Thermal Mapper (BTM). This aircraft flew missions on August 26 and August 28, monitoring fire mop-up.

Upon arrival at the fire camp, imagery records were interpreted in two phases. First, an initial readout was made for spot fires outside the line. These were plotted on aerial photos and maps. The information was then passed on to division and sector bosses for action. Second, a thorough analysis of the imagery was made for the following: Changes in fire perimeter, status of spot fires previously detected, mapping of tractor-built fire lines, and mapping of burned versus unburned and partially burned areas. The effectiveness of the previous evening's back-firing could be checked through the intense emissiveness of the burning area.

Elbert Reed is staff officer to the Medicine Wheel Ranger District, Bighorn, N.F.

Figure 1.—Scanning mission flown by: Forest Service Fire Scan System.
Date-Time: August 20, 1970, 0430 hrs.

The effectiveness and importance of thermal imagery as a fire fighting tool are aptly demonstrated by the following situations: The morning following a blowup on the southerly line, a spot fire was detected one-quarter mile south of the line, far beyond the area ordinarily checked by ground crews. When detected, the spot was 3 square feet. It was attacked within 1 hour of detection and after about 30 minutes it was cleaned up and declared out.

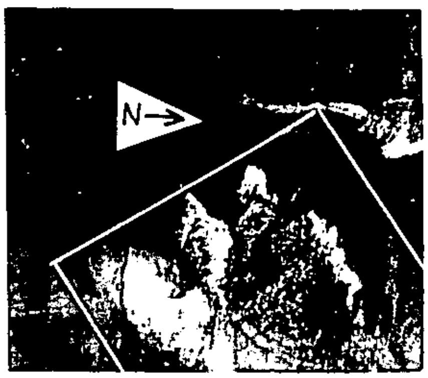
If thermal scanning had not been used, the fire boss estimated the fire would have burned one-quarter of an acre due to the location of the spot. It was estimated that this spot, under the existing burning conditions, might have increased 8 acres before control was attained. Suppression needs would have included one slurry drop, one tractor, and one inter-regional fire crew for 2 days. Estimated suppressions cost exceeded $2500. The estimated cost of the thermal imagery mission was $400.

Approximately 12 spot fires were detected by one or more of the thermal senors employed. These fires were controlled when they ranged in size from 4 square feet to 16 square feet. Not only did this prevent a major line loss, but it was a considerable savings of time and manpower over ground detection of these spots, many of which were putting out only whiffs of smoke. Accurate plotting of these spots enable a special 7-man team to quickly locate and extinguish them. A 25-man IR crew required for a combing operation would have been comparable.

How Sensitive Are Sensors?

This fire presented a good opportunity to compare three scanning systems. The table gives a

Figure 2.—Scanning mission flown by: U.S. Air Force, AN/AAS-18 System.
Date-Time: August 18, 1970, 0830 hrs.
Notice the same three-lobed fire pattern as in fig. 1.



quick breakdown on equipment and activity, and the following paragraphs evaluate each system.

Forest Service Fire Scan, Singer System.—Of the three systems employed, this system produced the best results. When employed at altitudes of 1,500 and 3,000 feet, the scanner produces (fig. 1) imagery of such a scale that interpretation is simplified. Image resolution is quite good at both of these elevations, enabling the interpreter to differentiate between hot spots (burning fuels), forested lands, non-forested lands, burned out areas, and partially burned out areas.

This system, utilizing polaroid prints, has several advantages. The first is timeliness. Within 30 minutes of mission completion, imagery is on the ground and in the hands of the fire staff. Poor imagery, due to a number of factors, can be discarded and a rerun made immediately. Both processing problems and delay due to processing time are eliminated.

Although thermal imagery has an inherent distortion, the Singer System has a minimum amount, compared to the other two systems used.

System reliability, based on ground checks, is essentially 100 percent. Spot fires, approximately 2 square feet, burning in duff with little or no smoke, were detected. The Singer System effectively met all criteria.

Table.—Equipment Used for Thermal Scanning and Missions Flown

Agency	*Aircraft*	*Sensor*	*Night Missions*	*Day Missions*
USAF	RF4C	AN/AAS-18	0	2
USDA FS	Beach Queen Air	Singer	4	1
USDI BLM	Unknown	Bendix	1	1

NOTE: Night missions include those at dawn when solar interference is negligible.

U.S. Air Force, AN/AAS-18 System.—This system was used at a flight altitude of 8,000 feet, producing a scale somewhat smaller than that of the Forest Service Singer System. Resolution is comparable to the Singer System and distortion is minimal.

The only defect noticed on this imagery is "ghost" haze along the scan lines on that portion of the imagery covering the extremely hot areas of the fire. Interpretation of hot spots posed no problem. Differentiation of forested lands, non-forested lands, burned out areas, etc. was difficult (if not impossible), due to the "ghost" haze mentioned above.

The greatest problem we encountered with use of the Air Force sensor was the time delay. In one instance 24 hours elapsed from mission completion until the fire staff received the imagery. Six hours of this was due to Air Force flight and processing time. The rest was due to ground travel and administrative holdup. During the early stages of a fire, immediate (2 hours maximum) receipt of the imagery is a necessity.

USDI, Bureau of Land Management, Bendix Thermal Mapper.—This system provided the least effective thermal imagery support. Flight altitude was 1,000 and 3,000 feet. At both altitudes, a scale similar to that of the Singer System was produced. Resolution was very poor. Scan lines were often quite heavy, obscuring the terrain map.

Interpretation of forest lands and non-forest lands was possible, but very difficult. Hot spots were quite readily picked up; reliability was about 60 percent. Ground checks of several indicated hot spots revealed nothing. A partial cause of this unreliability was due to the processing: Dirt or some foreign matter was on the film plane, the light source was directed against the film plane, or foreign matter got into the processing during development. Extreme distortion characterized this imagery and made plotting difficult.

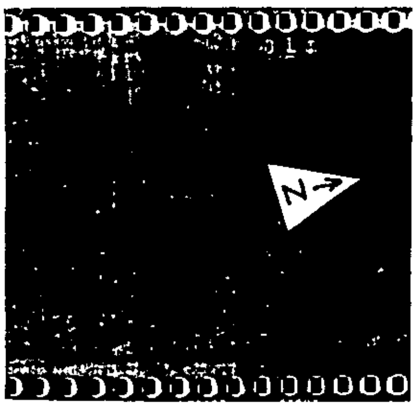
Delay between mission completion and ground delivery was usually about 4 hours. This is sufficient for mop-up operations on which the sensor was employed, but not sufficient for a fast-moving fire.

Imagery Is Versatile

Thermal imagery can be put to a number of uses in fire control. Primary is the detection of burning fuels and perimeter mapping. Rapid and accurate mapping of burned areas, partially burned areas, unburned areas, and location of tractor lines can be done.

This report was written to assist fire control personnel in the effective use of thermal mapping systems. The suggestions are those of the author based on discussions with the fire staff and pilot of the Forest Service fire scan aircraft, personal observations, and previous experience with using and reading out military thermal sensors. △

Figure 3.—Scanning mission flown by: Bureau of Land Management, Bendix System. Date-Time: August 28, 1970, 0500 hrs.



Small Airport Handles GIANT Mobilization

Francis B. Lufkin and William D. Moody

This article describes the impact of a fire bust on the North Cascades Smokejumper Base facility, its organization and its individual air operations. This article also outlines the safe and efficient, major-scale aerial operation which evolved.

Nestled in the Methow River Valley, on the Okanogan National Forest in North Central Washington, is the North Cascades Smokejumper Base (NCSB). It is normally a 36-man, 2-airplane Forest Service airport. It lies at 1,650 feet elevation and has a single, hard-surface, 5,000-ft.-long runway.

From July 16-31, 1970, NCSB became a major multi-function air, service, and supply, mobilization-demobilization center, operating around the clock. More than 350 people and over 50 aircraft were assigned to the total operation during the peak of the activity.

Smokejumper Force Grew

By the third day of the bust, the smokejumper force at NCSB grew to 176 men. Smokejumpers from every smokejumper unit in Regions 1, 4, 5, and 6 participated. In the first 4 days, July 16-19, 329 fire jumps were made.

Francis B. Lufkin is aerial project officer, North Cascades Smokejumper Base, Okanogan National Forest. William D. Moody is at the North Cascades Smokejumper Base.

Between July 15 and 27, 496 jumps were made on 85 fires, with a record 103 jumps made on July 16. The smokejumper demand was so great NCSB was out of jumpers several times during the first 8 days of the bust.

A high percentage of the jumps were made in extremely rugged country, under adverse wind and fire conditions. In spite of this and in spite of tremendous fatigue, only one serious and three minor jump injuries occurred.

3,000 Firefighters Arrived

Because it was close to fires on the Okanogan National Forest, NCSB became the logical mobilization-demobilization center for more than 3,000 firefighters.

After arriving at Moses Lake on large jets, the firefighter crews were shuttled to Omak, Wash., and NCSB by a fleet of DC-3's and DC-4's. Most crews were fed and bedded down at NCSB while waiting to transfer to fires or, later, waiting for demobilization aircraft. The NCSB messhall served 8,700 hot meals during one 10-day period.

Air Traffic Was Tight

For several days, air traffic at NCSB exceeded that of Spokane International Airport. Between July 16 and 19, 1,150 takeoffs and landings were made on NCSB's 5,000-ft. bituminus-surfaced airstrip. All air traffic advisory communications were handled by the NCSB dispatcher using Okanogan Forest Net, Airnet, or Unicom 122.8 mc. frequency. On the fifth day, a temporary FAA air traffic control station, operating out of the back of a pickup truck, was set up; it operated 24 hours a day. This was done because, while the Forest Service could not authorize straight-in landings and takeoffs, the FAA controller could. This traffic control station made possible more takeoffs and landings and eliminated aircraft "stacking" overhead.

Total air traffic between July 16 and 31 was recorded at 3,700 takeoffs and landings, all without incident. Temporary field lights permitted 24-hour airport use. Aircraft assigned to the fire included six smokejumper-cargo-dropping aircraft; eight DC-3's, one DC-4, and one C-46 passenger-freight transport aircraft; five air-attack lead planes; four aerial detection planes; and a fleet of small aircraft used for special missions and passenger haul. All fixed-wing, aerial-retardant aircraft operated out of Wenatchee or Omak airports, not NCSB.

Helicopter Operation

At the peak of activity, 23 helicopters, including six heavy turbines, were assigned to NCSB to form a helicopter pool. Priority jobs were assigned by General Headquarters and were handled by 39 heliport personnel. In the course of the bust the helicopters transported 10,201 passengers and 459,037 lbs. of cargo, dropped 860,320 gallons of water or retardant, and made several rescues of trapped or injured firefighters. All missions totaled 1,480 actual flight hours at the cost of $642,386. There were no accidents or reports of damaged equipment.

Fire Cache Grew, Too

Just as NCSB became the major manpower supply depot, it also became the major service and supply center for the western Okanogan National Forest. By truck, helicopter, and parachute hundreds of tons of supplies were delivered to fire camps from NCSB. Large helicopters played an important role in the delivery of much of the cargo.

Resupplied from the cache at Wenatchee, the 300-man Okanogan (NCSB) cache operated 24 hours a day. As the Wenatchee cache inventory drew down, NCSB ordered direct from GSA; private suppliers; Region 6 Fire Cache at Redmond, Oreg.; and from other out-of-the region caches.

After the crisis was over, NCSB again processed fire cache supplies and became the major center for all cache items being returned to Regional fire caches. Supervisory smokejumper and NCSB warehouseman, Terry McCabe and his crew, received, sorted, inventoried, weighed, and prepared supplies for delivery back to the Regional cache. Priority items such as radios were immediately returned to respective caches by airplane. This phase of NCSB's activity continued on a major scale until mid-October.

Organize! Organize!

With a fire bust and air operations of this scale, people arrived from all over the United States. It became necessary, for the sake of safety and efficiency, to reorganize the basic NCSB organization. By the fifth day of the fire bust, the "new" organization evolved (fig. 1). Listed below are a few of the key positions.

1. *Aerial Project Coordinator (APC):* NCSB's aerial project officer, Francis B. Lufkin, coordinated and managed all aerial project activities. In addition, he acted as liaison officer between incoming crews and the local community.

2. *NCSB Air Operations Officer (AOO):* This man, John Cowan, was responsible for aircraft safety, regulation enforcement, and wise and efficient use of all aircraft.

3. *NCSB Safety Officer:* A safety officer on a project of this size was a must. NCSB's, "Ole" Olsen, advised the AOO and APC on the overall safety of the operation. The organization operating under these positions is shown in figure 1. Figure 2 shows the organization of the helicopter operator.

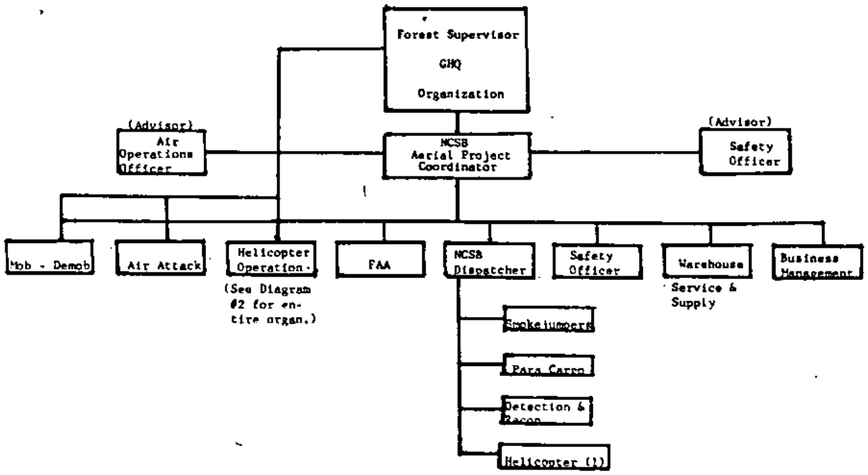


Figure 1.—This is an organization diagram of the interim North Cascades Smokejumper Base (NCSB).

Recommendations for a Safe and Efficient Air Operation

1. Establish an organization to insure the safest and most efficient total operation under *your* unique circumstances. Consider these key positions:
   a. Aerial project coordinator.
   b. Air operations officer.
   c. Project safety officer.
   d. Other experts for specific operations (such as local geography and weather conditions).

2. If you have heavy air traffic, consider setting up a temporary FAA air traffic controller.

3. Anticipate aircraft fuel needs, both quantity and type, including special helicopter fuels. Try to order at least 24 hours ahead of time.

4. Contract fuel trucks for aircraft refueling. This cuts down on gas pit congestion and delay.

5. Broadcast airport restrictions due to air traffic congestion, weather and visability problems, etc.

6. Gear your operation so phases do not impact each other. Assign qualified personnel to every operation, and operate 24 hours a day if necessary.

7. Anticipate and order special personnel to facilitate safety and efficiency. These people are valuable:
   a. Parachute riggers and repairmen.
   b. Cargo handler and cargo droppers.
   c. Gassing crews—24 hours a day.
   d. Loading and unloading crews (including a large forklift with operator).
   e. Business-personnel management people to handle

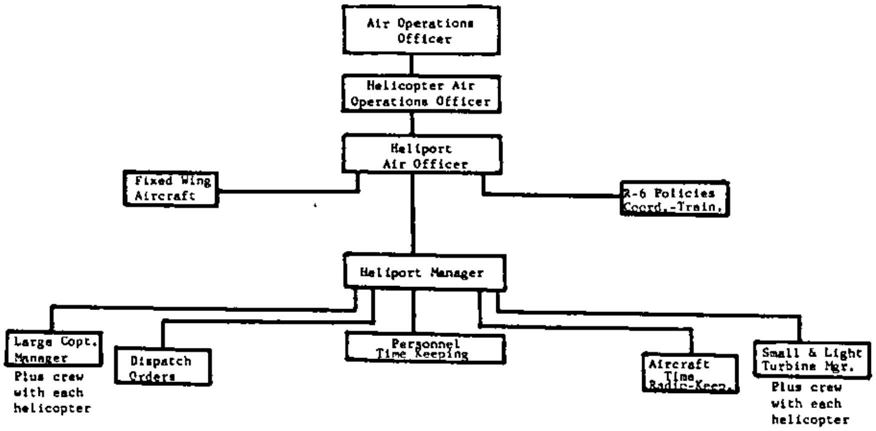


Figure 2.—This diagram shows the NCSB heliport organization.

time reports, accident reports, etc.

f. Carpenter.

g. General maintenance man.

h. Local service and supply and procurement personnel. These people are valuable in filling emergency orders from local sources for trailers, portable toilets, communications, etc.

9. Develop a communications link between all project operations. Provide enough phones and trunk lines so that all operations have good communications with the outside local fire organization.

10. Provide facilities for each operation. Identify them with signs. Eliminate congestion and conflicting "flow patterns."

11. Establish an information desk.

12. Anticipate and "be prepared" to handle and schedule routine daily activities such as personnel movement, air drops, etc.

13. Pre-train crews to perform warehouse-fire cache work including helicopter-paracargo cargo handling.

14. Provide fire protection for all facilities, operations, and aircraft. Contract for local rural fire department equipment that can use foam fire retardant.

15. Consult the FAA Engineers for recommendations concerning safety procedures, etc. after estimating what the air traffic impact will be.

16. Provide adequate signs to keep unauthorized ground equipment and personnel away from aircraft and operations areas and off runways. Make use of local law enforcement officers if necessary.

17. Set up food-preparation facilities and outdoor coffee stands. Consider use of frozen meals and rations for emergency situations.

18. Order commercial, portable chemical toilets to supplement "indoor" facilities. Place some near crew loading-unloading areas.

19. Provide ground transportation for aircraft crews and other overhead to motels and restaurants. Consider rental cars, etc.

20. Have a liaison officer working between local, Forest, aerial project coordinator (APC), incoming crews, and local community.

21. Provide aircraft parking areas for aircraft out-of-service due to pilot, flight-time restrictions, needed repairs, waits for crews or equipment, etc.

Smokejumper Recommendations

1. Thoroughly brief all incoming jumper crews of unit policies and procedures, fire situations, facilities, etc. Issue special equipment as needed.

2. Have home-unit spotters spot or supervise all smokejumper missions.

3. "Ground" jumpers, pilots, or spotters, when they are overly fatigued.

4. Keep spotters and jumpers current on fire weather and other conditions in the area.

5. Do not let spotters be tempted to deviate from standard practices and safe procedures.

6. Be sure spotters hold short safety meetings periodically to discuss jump and fire conditions and problems encountered. Remind the crews of safety objectives and of safety measures that compensate for fatigue and complacency.

Helicopter Recommendations

1. Keep operation area as dust free as possible. Initiate dust abatement measures early.

2. Enforce use of all helicopter-operation safety equipment.

3. See that helicopter operations are directed by heliattack-qualified personnel.

4. Anticipate the need for special fuel, such as turbine fuel.

Summary

The July 1970 Okanogan National Forest fire bust became a major impact on the North Cascades Smokejumper Base. Through teamwork, dedication to the task, and cooperation, the organization at the small airport handled a giant mobilization efficiently and safely.

Perhaps this experience and these recommendations will be of value to you if you should ever become involved in a similar major aerial fire suppression operation. △

Probability Forecasts Need Revision

Robert E. Lynott

A simple aspect of probability forecasting for weather is "probably" overlooked by many forecasters and users of the forecasts: Are such forecasts revised as frequently as needed?

A probability forecast is the evaluation of weather conditions existing at the *particular time* of the forecast. At any later time, that evaluation can usually be revised.

Regardless of the numerical value used for the stated probability, 10-percent chance of rain, for instance, the predicted event either does or does not occur. Perfect forecast accuracy is attained only in two combinations of circumstances, when a forecast of 100-percent probability is followed by occurrence or when a forecast of 0-percent probability is followed by nonoccurrence.

R. E. Lynott is meteorologist, Division of Fire Control, USDA Forest Service, Portland, Oreg.

Degree of Accuracy

Because perfect forecast accuracy is not attainable for weather events, values between 100 and 0 are predicted. This is tacit admission that absolute accuracy is not possible. Nevertheless, the intermediate values are useful in a statistical sense. The user can take or forego action on the basis of his cost-benefit ratio.

An evaluation of the accuracy of probability forecasts is meaningful only if a large number of forecasts are evaluated. A single forecast cannot be evaluated by itself unless it is a "yes" or a "no" forecast.

Proper attention to the time factor must not be neglected in the use of probability forecasts. Usually, current weather conditions can be monitored continuously by a forecaster from the time of the original forecast until the forecast period expires. Assuming such monitoring, and assuming that forecast accuracy improves as the time period decreases, it becomes a general truth that any probability forecast can be successively revised until it reaches the perfect accuracy of either 100 percent, occurrence, or 0 percent, nonoccurrence.

The question for all concerned is whether such revision is being done whenever appropriate, that is, when sufficient use can be made of the revised values, at points in time nearer to the end of the period. Users may mistakenly assume that such improved revisions are not possible. Forecasters may mistakenly assume that users use revisions for shorter periods. Then again, there are circumstances where frequent revisions of forecast probability are not practical or useful.

But forecast users should review all pertinent operations. They should consult with forecasters about possible opportunities for this aspect of probability forecasting.

For Instance

With respect to the occurrence of lightning in Oregon and Washington, the actual incidence of thunderstorms is important enough to fire control personnel that such reports are immediately relayed by teletype to all appropriate National Forests and other management units; in so doing, the probability forecast is revised. Lightning changes the actions of the forecast users even on very short advance notice. In effect, lightning in an adjacent area causes the *user* to revise the probability in his area to a high number, say 90 percent, regardless of the earlier probability forecast.

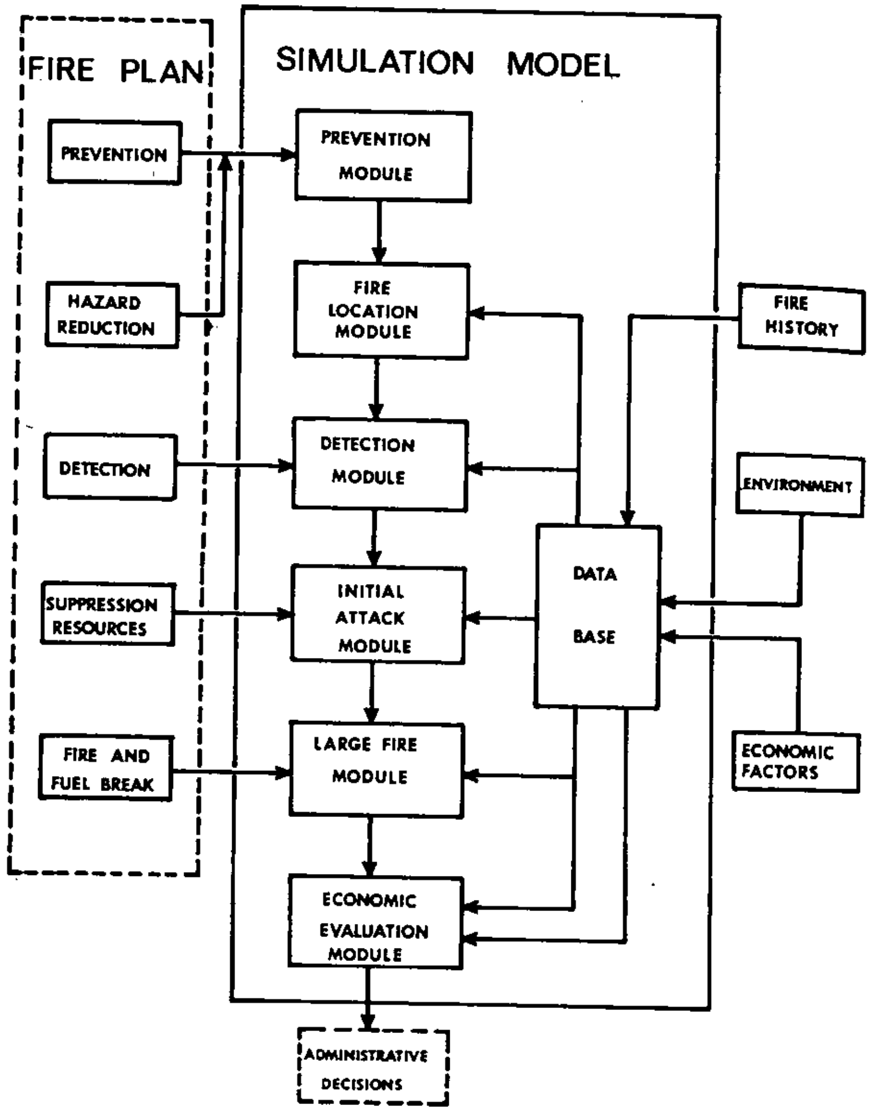
Perishable Forecasts

The purpose of this discussion is to remind forecast users that probability forecasts are extremely perishable. They can be revised by weather forecasters to approach 100 percent or 0 percent as time progresses. Would such revision be useful to you? ▵

Computer Simulates Fire Planning Problem

Robert L. Bjornsen and Richard A. Chase

Are you a "what if" fire planner? How many times have you speculated: What if I introduce a new prevention program or change from fixed to aerial detection or redeploy initial attack forces or build a network of fuel breaks? Will it reduce fire occurrence and damage? If so, what are the probable economic consequences of the alternative selected?



Simulation model design and flow

Simulation: Modeling Reality

What you need is a better way to predict the probable consequences of available alternatives, a way which avoids the pitfalls of guessing but does not involve the costs and delays of experimentation and pilot testing. Simulation is an answer, and FOCUS,[1] the Fire Management Systems project at the Riverside Fire Laboratory, is our simulation model.

With simulation, planners and managers can propose changes and test ideas with no risk. The probable long-term consequences of alternative courses of action can be compared because simulation allows components of the system and their relationships to be changed to reflect the introduction of new equipment, new techniques, and different configurations.

Through use of a large modern computer, which can perform many thousand calculations a second, the operation of a system can be repeated many times in a few minutes. This process permits variability found in the "real world" and permits some feeling to be gained for the most likely consequences of a given alternative. Since many years of operation of a system can be simulated in a relatively short time, the manager can quickly receive an objective analysis of probable long-range strengths and weaknesses of alternative courses of action. Armed with this knowledge, he is in a much better position to make a good decision than if he were forced to use only his own judgment.

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[1] Fire Plan Operation Characteristics Using Simulation

Model Design and Operation

The components and operation of the simulation model are shown in the figure. To work with the model the fire planner specifies prevention and hazard reduction programs; the detection system; the kind, amount, and location of initial attack forces; dispatch decision rules; and fire and fuel break systems. Thereafter the plan will be tested against a series of simulated fires to find potential weaknesses and predict economic consequences.

For each fire tested, the model will calculate travel times of various forces (ground and air) dispatched to the fire. It will then compare their fireline production rates with the fire's rate of perimeter increase from time of arrival, and will determine if available initial attack forces can contain the fire and at what size. The model will also determine size of those fires escaping initial attack and will evaluate economic consequences of the resulting large fire according to resources involved and probable fire intensity.

Data Makes It Run

A data base provides the model with information necessary to simulate its particular fire problems. From data stored on past fire occurrence, risk, weather, fuels, and topography, the model generates realistic lightning and man-caused fire starts (see figure). Until effective control action contains each fire generated, the fire size increases at a rate consistent with the given fuel and slope and the probable fire danger expected at the time.

Other data base items include types and locations of permanent fire control facilities, locations of and travel times over the transportation system, and any constraints which physical conditions or management policy may impose on use of certain equipment, tactics, etc. in any location. Also stored are data relative to potential resource damages.

FOCUS Today

Employing a team of operations analysts, mathematicians, and foresters, early development work on FOCUS has concentrated mainly on fire location and initial attack modules and on data base design. Preliminary working versions of these are being evaluated using data from a test area on the Tonto National Forest, Arizona. Meanwhile, only lightning firepatterns are being tested in the simulation process. Man-caused fires present a more complex problem in prediction, and the development of sound statistical approaches to their use has proceeded at a slower rate.

Pending development of a model for predicting actions of large fires, determination of final size and shape of those fires escaping initial attack will probably be based largely upon previous experience with class C and larger fires.

When fully developed, FOCUS will be able to simulate fire problems of a particular area and evaluate probable long-term effects of various protection plans. FOCUS will provide the planner with some feel for the strengths and weaknesses of alternative plans and permit him to see how innovations will affect patterns of fire occurrence and fire escapes. Ultimately, FOCUS will also give a measure of the net economic consequences to be expected from a particular alternative and thus provide a rational basis for the justification of budget requests and for allocation of funds. △

Automated Fire-Danger Rating Works

Howard E. Graham

The Pacific Northwest Federal Agencies have an operational automated fire-danger rating procedure that solves the problem of data analysis and data display and provides uniform accurate computations. This article describes the benefits and the procedure.

The Pacific Northwest Region of the Forest Service, together with several cooperating agencies, has solved many fire-danger data management problems related to fire danger ratings. This was done by developing an automated procedure.

Some of our problems were:

1. Fire Control units and fire-weather forecasters frequently arrived at different conclusions concerning the magnitude of current conditions.
2. Fire-danger ratings were often inconsistent from area to area. The weather at any one place is always related to nearby weather, but some of the ratings did not reflect this principle.
3. Headquarters units, such as the Regional Office, had difficulty maintaining awareness of fire danger.
4. It was virtually impossible to determine accuracy of fire-weather forecasts.

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How Automation Works

Prerequisites

In the Pacific Northwest, several steps were taken to remove all possible error from the process involved in applying observed weather and weather forecasts to presuppression. These steps were considered necessary before an automated data management procedure could be developed:

1. *Weather zones defined.*—Fire-weather forecast areas were defined to conform primarily to weather zones instead of administrative boundaries. There was a rational basis for this: On most fire season days, the weather condition is usually the same over extensive areas of similar elevation, topographic type, and cover type. Reasonably homogenous fire-weather conditions, hence, fire danger, with the possible exception of human risk, are to be expected within each zone. The forthcoming National Fire-Danger Rating System (NFDRS) calls for zones. Any new zones should be established according to NFDRS guidelines.

2. *Forecast and rating elevation defined.*—A forecast and fire-danger rating elevation was defined for each zone at approximately the mean elevation. Fire weather is predicted and fire danger is computed for this forecast and rating elevation. The advantages here are that both the weather forecaster and the user are aware of specific targets for forecasting weather.

3. *Location of fire-danger stations.*—Fire-danger stations are generally located within 1,000 feet of the zone forecast and rating elevation and spaced as evenly as possible around the zone center. To determine a reliable measure of current conditions and to provide forecasts for the mean elevation, weather data that directly measure the well-exposed mean conditions are needed. Lack of properly located observation stations creates a distinct handicap in attempts to compare actual and predicted fire weather. Consequently, special efforts were to provide properly located weather stations.

4. *Reliable communications system.*—A rapid and reliable communications system is essential. Region 6 and the cooperating agencies have teletype communications that can be scheduled to meet the needs for this automated procedure.

Data Flow

Observed fire-weather data are transmitted to the computer. Some of these data are from automatic telemetering stations and some from manual stations. The computer analyzes the observed data and issues current zone weather averages. Using these data as starting points, fire-weather forecasters issue values of expected weather by zones. The computer converts these predicted weather elements to predicted burning index. At the same time, the predicted values are summarized as needed and automatically addressed to users. Each predicted zone burning index is automatically checked against frequency of occurrence tables. When an unusually high burning index is predicted, a special alert is issued calling attention to the situation. Examples of the two types of special alerts issued are below:

1. "Special Alert—Predicted BI for zones listed below have occurred on the average of 5 percent or less of the days July-September 15, 1961-1968."

2. "Special Alert—Precicted BI for zones listed below exceeds any previous observed BI July-September 15, 1961-1968."

Advantages of Automation

The automated procedure has two significant advantages. It allows the management of the large quantity of data to become systematic, and it produces data analyses and data displays never before available.

Data Analyses

1. *Analysis of observed data.*—The process of determining predicted fire danger first involves determining current conditions. An individual weather observation does not, by itself, provide a very accurate indication of the area-wide current weather needed for presuppression planning. Current conditions are best indicated by an integration of several observations. Following this principle, we have developed a procedure for statistical analysis that determines current conditions by weather zones. Conditions defined are zone averages of temperature, relative humidity, wind speed, precipitation, buildup index, and burning index. All analyses are done accurately and uniformly regardless of location or the Federal agency involved. The result of this systematic procedure is much more useful because it provides a complete Regional view, area by area, and provides logical connection between adjacent areas.

2. *Provides data summaries.*—Not only is fire danger determined by weather zones but summaries of fire danger are produced for broad sections of the Region. The summaries provide a broad overview for the Region's fire control operations.

3. *Verification studies.*—Up to now, little has been known about the improved protection that could be obtained through use of the morning forecast in-

stead of the previous afternoon forecast. But we will soon know because forecasts are being verified. Other questions that apply to protection problems need to be answered; for example, what success does the forecaster usually have in predicting marked weather changes. Forthcoming answers to these will benefit the fire control effort. Some fire control systems may need to be redesigned to fit the forecast accuracy.

Data Displays

1. *Comparison of observed and predicted values.*—What conditions were forecast and what actually happened? This information is displayed daily on teletype shortly after basic observation time. Listed by weather zones are both current zone weather averages and predicted values (fig.). Thus, all user agencies and forecasters have ready access to comparative values of what was predicted and what actually happened. For the first time forecasting accuracy can be determined.

2. *Predicted burning indexes.*—Predicted burning indexes by zones are displayed on teletype in map form twice daily to all offices. Through use of a transparent overlay, the user has a quick visual plot of weather zone burning index over the States of Oregon and Washington. (See *Fire Contr. Notes,* 31(4):12, 1970.)

Teletype display of observed and predicted conditions.

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M
1455 PDT 08/23/70 - PREVIOUS FCSTS AND CURRENT OBSVD FDR AND WEATHER.
OBSVD DATA 1400 PDT TDA - DATA ARE ZONE - 24 HR AVG RAIN - CURRENT BUI.
YDA AFTN FCST TIME - FCST COMPARED TO AVG OBSVD - BI-TEMP-RH-WIND.
THIS MRNG FCST TIME - FCST COMPARED TO AVG OBSVD - BI-TEMP-RH-WIND.
.
SALEM FCST RESPONSIBILITY    .
312-000-104--1500-0400-064054-6894-1208--0800-0400-064054-6894-1008.
313-001-100--1500-0300-063058-6983-1007--0800-0400-063058-6883-0907.
314-001-132--1500-1100-068055-5892-0705--0800-1100-066055-6092-0805.
316-000-160--1500-1301-080061-5282-0606--0800-1101-072061-5482-0506.
317-001-064--1500-0901-068064-6079-0805--0800-0901-066064-6279-0805.
320-001-080--1500-1000-065057-5881-0705--0800-1000-065057-6081-0805.
MEDFORD FCST RESPONSIBILITY  .
302-000-223--1500-2110-076066-4060-0706--0800-1810-074066-4560-0706.
303-000-280--1500-3031-084079-2623-0808--0800-2831-082079-3023-0808.
305-000-228--1500-2929-085083-2423-0707--0800-//29-///083-//23-//07.
306-000-236--1500-3134-082080-2418-0808--0800-//34-///080-//18-//08.
329-000-357--1500-3746-085084-1714-0912--0800-//46-///084-//14-//12.
330-001-354--1500-3851-087086-1513-0914--0800-//51-///086-//13-//14.
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PORTLAND FCST RESPONSIBILITY .
307-000-230--1500-2830-078078-3427-0908--0800-2730-076078-3227-0808.
308-000-231--1500-2835-081081-3425-0910--0800-2935-082081-3225-0910.
322-000-215--1500-2225-078079-3932-0707--0800-2025-076079-4332-0707.
323-000-233--1500-2828-075079-2930-0808--0800-2828-076079-2730-0708.
324-000-201--1500-2220-078078-3942-0707--0800-2020-076078-4242-0707.
325-000-200--1500-2217-078075-3949-0708--0800-1917-076075-4349-0708.
326-000-241--1500-3028-082083-2734-0809--0800-3128-084083-2434-0809.
327-000-347--1500-2531-086090-2325-0505--0800-3731-094090-2425-0705.
328-000-319--1500-3040-082086-2216-0710--0800-3740-090086-2316-0710.
390-000-196--1500-2112-080075-4452-0905--0800-2012-077075-4752-0905.
425-000-138--1500-2916-080077-3046-0906--0800-2716-080077-3046-0806.
426-000-248--1500-3123-083080-2342-0809--0800-2823-083080-2942-0809.
427-000-122--1500-2418-083079-3746-0908--0800-2118-082079-4046-0808.
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PENDLETON FCST RESPONSIBILITY.
331-000-366--1500-//43-///088-//14-//11--0800-//43-///088-//14-//11.
332-000-283--1500-3127-086085-1518-0605--0800-//27-///085-//18-//05.
333-000-262--1500-3844-094091-1522-0609--0800-//44-///091-//22-//09.
334-000-230--1500-2930-085087-1816-0606--0800-//30-///087-//16-//06.
336-000-276--1500-3335-087086-1516-0708--0800-//35-///086-//16-//08.
337-001-302--1500-3633-088087-1514-0807--0800-//33-///087-//14-//07.
338-001-278--1500-4337-083079-1817-1209--0800-//37-///079-//17-//09.
339-000-294--1500-4036-095095-1619-0706--0800-//36-///095-//19-//06.
340-000-196--1500-2733-089090-1818-0505--0800-//33-///090-//18-//05.
341-000-197--1500-3132-084085-1816-0707--0800-//32-///085-//16-//07.
342-000-186--1500-2933-086085-1815-0607--0800-//33-///085-//15-//07.
343-000-146--1500-3238-085086-1613-0709--0800-//38-///086-//13-//09.
344-000-126--1500-3637-079081-2017-1010--0800-//37-///081-//17-//10.
345-000-238--1500-3728-095097-1717-0603--0800-//28-///097-//17-//03.
346-000-163--1500-2937-085088-1815-0609--0800-//37-///088-//15-//09.
```

Benefits to You

Certain benefits from this automated procedure can be recognized immediately:

1. It eliminates much ambiguity about weather conditions. The new, more homogenous weather zones, with their defined forecast and fire-danger rating elevations and with their more representative observation stations, provide the forecaster and forecast user alike with a specifically defined frame of reference.

2. It reduces fire control work load. Less communication and less manipulation of weather data is required.

3. And, most important, it performs these processes uniformly and accurately.

The automated procedure incorporates a number of successfully tested procedures into an effective fire control manager's tool. This type of streamlining is necessary to provide the best presuppression protection and to get the most out of the new National Fire-Danger Rating System—or any fire-danger rating system for that matter. Δ

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1971 . . . Commemorative Year Of America's Most Disastrous Forest Fire

Many Americans know of the disastrous Chicago Fire, but few know of the Peshtigo Fire — America's most disastrous forest fire. Both fires occurred on October 8, 1871. Two hundred lives were lost in the Chicago Fire; 1,300 lives [1] were lost in the Peshtigo Fire; 2,240 acres burned in the Chicago Fire; 1,280 thousand acres burned in the Peshtigo Fire.

Dry Weather

The unusual climatic conditions accompanying these fires should be noted because they could occur in the future: (1) Below-normal precipitation for 3 to 8 months, (2) low vegetation in draught or wilting stage for 1⅓ to 2½ months, (3) long-term below-normal humidity, and (4) above-average sunshine duration. The daily weather patterns that preceded these fires were not unique.[2] [3]

A Legal Consequence

The Peshtigo holocaust forcibly brought the seriousness of the forest fire menace to the attention of the public. The result was a law (CH. 285, Wis. Laws of 1873) prohibiting burning in woods, prairies, or in cranberry bogs between August 1 and November 30. This law served to establish the principles of a closed season on burning in Wisconsin.[4]

Peshtigo Today

Peshtigo, Wis., has become a thriving manufacturing center. The forest has grown back and is providing raw material for industry and a place for relaxation and recreation. The community has issued a Peshtigo Fire Centennial Coin depicting the city reborn from the ashes of America's most disastrous forest fire.

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[1] R. W. Wells. Fire at Peshtigo. Prentice-Hall, Englewood, N.J., 243 p., 1968.

[2] Donald A. Haines and Rodney W. Sando, Climatic conditions preceding historically great fires in the North Central Region. USDA Forest Serv., N. Cent. Forest and Range Exp. Sta., Research Pap. NC-34, 19 p., 1969.

[3] Donald Haines and Earl L. Kuehnast. When the Midwest burned. Reprinted from Weatherwise, vol. 23, no. 3, June 1970.

[4] J. A. Mitchel and Neil LeMay. Forest fires and forest fire control in Wisconsin. Wis. Conserv. Comm. in coop. with USDA Forest Serv., 75 p., 1952.

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