REMOTE SENSING IN FOREST FIRE CONTROL REPORT ON SYMPOSIUM JUNE 1971 MISSOULA, MONTANA

by

J. Niederleitner

NORTHERN FOREST RESEARCH CENTRE
EDMONTON, ALBERTA
INTERNAL REPORT NOR-1

CANADIAN FORESTRY SERVICE
DEPARTMENT OF THE ENVIRONMENT
AUGUST 1971

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ABSTRACT

The symposium[1] was primarily concerned with the remote sensing hardware developed by the "Northern Forest Fire Laboratory, U.S.D.A." in Missoula, Montana, and took the form of "progress reports" on various remote sensing projects.

With available equipment it is now possible to:

(a) Remotely sense and record fire causing lightning and to track and locate lightning storms;

(b) Accomplish primary fire detection with airborne infra red devices through smoke or at night;

(c) Assist visual aerial patrols in locating by means of the "Airborne Fire Spotter" fires no longer emitting smoke;

(d) Map the perimeter and the characteristics of fires completely obscurred by smoke.

Infrared - (I/R) systems are offering another dimension in fire detection by being able to detect fires not detectable by other means. However, at the conclusion of the symposium we were not convinced that I/R fire detection is more efficient, cheaper or better than visual detection. It is unlikely, at least at this time, that I/R systems can totally replace any of the visual means of detection, although it could eliminate some lookouts or aerial patrols. I/R detection, as treated in Missoula, is a form of intermediate detection replacing visual aerial patrols more so than fixed detectors.

Other aspects pertaining to fire detection such as trends in detection techniques, the status of lookouts and aerial patrols and the planning of detection systems were also discussed.

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[1]Sponsored by the Division of Forest Fire and Atmospheric Sciences Research USDA, Missoula, Montana, June 1 - June 3, 1971.

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INTRODUCTION

The Remote Sensing Symposium was designed to familiarize interested parties with the present state in remote sensing technology. Messrs. Stanley N. Hirsch, Ralph A. Wilson, Dr. Peter Kourtz, Robert F. Kruckeberg and Charles W. Schmid presented papers on the history, scope, application of remote sensing and the state of infrared fire surveillance equipment; the principles and fundamentals of remote sensing; the economics and operations research methods pertaining to fire detection; the operation of I/R sensing equipment and the planning of detection systems; and the state of remote lightning sensing equipment, respectively.

In addition to the 37 American attendees who represented the forest services and allied organizations of seven states, there were five representatives of the Canadian forest services. Only one Canadian, Mr. George Rogers of the National and Historic Parks Branch, represented an agency served by the Northern Forest Research Centre.

This report was prepared for the benefit of the fire control agencies in western Canada that did not have the opportunity to obtain first hand information through a representative of their own.

Reprints of the publications listed in Appendix 2 can be obtained from the originating agencies.

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[2] Forest Research Technician, Northern Forest Research Centre, Edmonton, Alberta.

REMOTE LIGHTNING SENSING SYSTEMS[3]

The remote lightning sensing system (basically an arrangement of oscillographs) appears to be a very necessary mate to any intermediate detection system such as aerial visual or I/R patrols where man collected weather information is not available. It should be a part of any remote weather sensing system such as the "Computing Devices of Canada Ltd. - Phi Tran".

1. Fire Causing Lightning.

Every lightning strike is a tremendous surge of electrical current which causes a momentary change in the earth's electrostatic field. This change can be recorded as a "trace" on the oscillograph of the lightning sensing system.

(a) Each lightning strike produces a different trace. Certain characteristics of each trace are peculiar only to certain types of lightning. For example it has been demonstrated that some cloud to ground lightning shows a phase of "long continuing current" (LCC) flow after the last return stroke. This phase is not perceptible to the visual observer. Lightning exhibiting this LCC phase appears to be responsible for most lightning fires.

(b) Cloud to cloud lightning causes a different trace than cloud to ground lightning. Thus the lightning sensing system not only detects lightning, it identifies the cloud to cloud and the cloud to ground lightning and can separate the "scorcher" from the harmless discharge.

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[3] One prototype of such a system exists. Specifications for the system can be obtained from the Northern Forest Fire Laboratory, U.S.D.A., at Missoula. Cost per sensor is approximately $500. Cost per monitor station, depending on the number of sensors is $100,000.

2. Methods of Remote Lightning Sensing.

Most of the lightning sensing equipment discussed at the symposium was designed to measure the earth's electrostatic field. Sensors pick up electrostatic field changes through their antennas. A remotely located or on site oscillograph records each strike. The resulting traces on the oscillograph show the number and intensity of changes in the electric field for each strike.

The oscillograph registers each strike and thus acts as an automatic lightning counter. However, it is possible that simultaneous or near simultaneous strikes within the range of one sensor could register as one complicated trace so presenting problems in the interpretation. The sensitivity of electrostatic field sensors is non-directional, but, if the sensors are purposely restricted in range, let's say to 20 miles and a network of sensors spaced 30 miles apart is set out, only a few sensors would respond to each strike. Thus zones of potentially dangerous lightning strikes can be charted by the location of sensors responding to each strike.

Photoelectrical recordings of the flash with luminosity meters and radio wave or magnetometer recordings are other methods of remote lightning sensing. Some of these methods were tested in Missoula, but none was as well suited for remote lightning sensing as electrostatic field measurements with the oscillograph.

The lightning sensing system supplements weather radar of 10 cm wave length, type WSP57, which is used to locate and trace storms (5 cm and 3 cm wave length radar apparently is too limited in range to be useful for that purpose). Radar can establish the position, movement, height and growth of a cloud, but it cannot tell where lightning has struck.

3. Operation of a Remote Lightning Sensing System.

Electrostatic field sensors are self contained units complete with batteries which are placed into position before the start of the lightning season and are collected at the end of the season. A central monitor station receives and records the transmissions received from each sensor. The system is activated by remote control when the weather radar reports a storm moving into the sensor grid area. Interpreters would read the traces and plot dangerous strike patterns.

PRIMARY FIRE DETECTION WITH AIRBORNE I/R DEVICES[4]

A new development in remote sensing, the bispectral I/R scanning system offers the opportunity of primary fire detection with an I/R device. The addition of I/R to existing detection systems will most likely increase the overall detection costs but should result in a better detection system and in correspondingly lower suppression costs and fire losses.

1. Past Limitations of I/R Line Scanners.

To this date it was thought that airborne I/R hardware was not suited for primary fire detection, because of a number of inherent limitations. Some of these limitations are:

(a) Only a very narrow strip of ground (approx. 2 miles) can be covered if the scanner is flown low enough to pick up small targets.

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[4] Only one bispectral I/R scanning system (FFS II/RS 7) suited for primary fire detection exists at this time. This system could be manufactured to order by an electronics firm. Most components employed in the system are ready made commercial parts. Specifications can be obtained from the Northern Forest Fire Laboratory at Missoula.

A complete bispectral I/R scanning system including Doppler Navigation equipment as it is used at Missoula costs $134,000 (US funds). The Canadian price will be around $200,000.

(b) Excessive problems exist in navigation and high costs of operations are incurred by flying narrow strips.

(c) The lack of a monitor or instant film printout in the aircraft prevents the operator from precise adjustments and identification of ground features.

(d) Excessive distortion of the imagery caused by aircraft roll and inherent weakness in systems design is common.

(e) Lack of reliability of the system, malfunctions and false alarms.

(f) Poor definition and background resolution of the imagery. Furthermore, I/R radiation does not penetrate clouds, heavy fog and solid matter such as tree foliage, tree boles or duff that may obstruct the direct line of sight between the hot spot and the I/R sensor.

2. Recent Improvements - The Bispectral System.

An I/R line scanning system specifically designed for primary fire detection which eliminates or reduces the common drawbacks of I/R scanning systems was built and tested on an operational basis in Missoula by the Division of Forest Fire and Atmospheric Science Research. It is called the "bispectral" system because the sensors work through two I/R channels.

The bispectral system functions roughly as follows: While normal I/R scanning systems (monospectral) scan only one channel, the bispectral system scans two channels simultaneously, 3 to 4 microns and 8.5 to 11 microns and compares the radiation sensed through each channel.

Of the two channels, the 3 to 4 micron channel is especially sensitive to radiation as it is emitted from fires. The 8.5 to 11 micron channel is sensitive to typical background radiation.

The smallest area that a two "milliradians" scanner can "see" from 15,000 feet altitude above ground is 30 x 30 feet. If a fire exists in that plot, the energy emitted from that fire is averaged over the entire 30 x 30 foot area. A fairly large hot target will raise the average temperature of the plot enough to register as a fire, while a small fire, particularly if it is not all in the open, will raise the total energy radiated by the plot only a few degrees. Thus a scanner working in the 3 to 4 micron range, sensitive to one centrigrade degree would respond by assigning this plot a different shade of grey. The scanner could not tell that this small temperature rise was caused by a fire, since small temperature variations from plot to plot are common in most terrain. The same happens on the 3-4 microns channel of the bispectral system. It too only senses a different shade of grey. Alternatively the 8.5 - 11 micron channel of the bispectral system, which is rather insensitive to energy radiated by fire, does not detect any difference since the background radiation from the sensed plot is the same as from the surrounding plots. Now the bispectral system compares the signals received through both channels - reversing the signal of one to cancel the other. In absence of fire, the signal received through both channels is exactly the same and a complete cancellation takes place. However, if there is a fire, the slight difference in the 3-4 micron channel which cannot be cancelled, triggers the TARGET DISCRIMINATION MODULE (TDM), which marks the location of the fire.

The advantages of the "FFSII Bispectral I/R Line Scanning System" can be summarized as follows:

(a) The "resolution" or sensitivity to fires is improved better than tenfold over conventional monospectral scanners.

(b) Because of the better resolution patrols can be flown at altitudes of 20,000 or 30,000 feet, widening the ground coverage to ten and fifteen miles, respectively. From 20,000' altitude the system is capable of detecting a 600°C target of one square foot against a nighttime background.

(c) Precise navigation can be accomplished by equipping the patrol aircraft with a "Doppler" radar navigation system complete with compass and computer.

(d) A near real time (high speed) film processing unit provides the imagery on a dry film ready for interpretation in the aircraft. The interpreter, who is also the equipment operator, verifies the aircraft's course from the imagery, identifies the recorded hot spots, separates known fires from wild fires and adjusts the system to obtain the highest quality of imagery.

(e) The system has built in distortion compensation and a roll gyro to minimize imagery displacement caused by the pitch and roll of the aircraft. (The imagery is still distorted as compared to an aerial photograph).

(f) The "Target Discrimination Module, (TDM)", a built-in device, warns the interpreter when a hot target is scanned by placing a white mark immediately beside the target and another one at the margin of the film. The TDM is only triggered when a hot target is sensed at the same spot twice during two successive scan lines. This serves as a safeguard against false alarms caused by fluctuation in the electrical current.

(g) True mile markers generated by the Doppler radar system appear as a row of dots - one for each nautical mile - along the margin of the film.

(h) The new unit is claimed to be relatively trouble free. In 1970 it operated 265 hours without a failure.

3. Operating a Bispectral I/R System (FFS II/RS 7).

The I/R bispectral system was tested operationally in 1970 over an area of 8200 square miles situated adjacent to Missoula, Montana. Fire detection patrol flights of a duration of 5½ hours each were flown from July to September following a continuous grid pattern. A north-south grid was followed during night patrols and an east-west pattern during day patrols. The I/R patrol passed over 203 known fires and detected 103 of them. Of the 103 detections, 44 were "firsts", the other 59 fires were already known to the visual detection system which consisted of 59 lookouts and 6 patrol aircraft.

Aircraft Requirements for Bispectral I/R Systems:

In order to make full use of the I/R system the patrol aircraft must be suited to fly both at high altitudes (20,000 to 30,000 feet) and at low altitudes at speeds in excess of 200 miles per hour, therefore jet aircraft were found to be unsuited because too much flying is required below the altitude of a jet's efficiency. The aircraft used in Missoula was a Beechcraft King Air, Model 65 B 80, twin turboprop, light executive aircraft, with pressurized cabin. Some of the I/R instrumentation was built into the floors and walls of the aircraft.

Personnel Requirements for the I/R Bispectral System:

The I/R patrol crew consists of the pilot and the equipment operator-interpreter. More than one crew would be required to operate the equipment on a full time basis. There is also a need for ground support personnel such as technicians to service the I/R system and for radio operators to stand by during night patrols.

Identification and Reporting of Fires:

The processed negative film leaves the scanner as a continuous strip. Two minutes after exposure, the interpreter compares the film against his patrol map, annotates the hot spots registered on the film and, after eliminating known fires, transfers the detected wild fires onto his map using the drainage pattern as a guide. Obtaining the legal description from the map, he reports the location of the fire to headquarters during turns between flight lines. No radio transmissions are conducted while on the patrol route in order to prevent interference with the I/R system. During night patrols or in heavy smoke the I/R crew have no visual contact with the ground and depend entirely on the imagery on the film for fire detection and orientation. A number of I/R imagery film which were taken over the test area west of Missoula were shown at the symposium. All of them had good background definition. The test area consisted of alpine and subalpine terrain with distinctive drainage detail. Even over this terrain, rich in recognizable topographic detail, it was impossible to navigate without the benefits of the "Doppler" navigation system. Since there was no way for the I/R crew to place a marker on fires that they discovered, the suppression crew need their own I/R equipment (AIRBORNE FIRE SPOTTER) to ferret out latent fires reported by the I/R patrol.

4. Economics of Primary I/R Detection.

The cost of I/R detection was given as 6 cents per square mile per observation or $200 per aircraft operating hour. This would make I/R detection competitive with visual aerial detection and cheaper than ground detection as it exists in the study area. There was no indication as to how many visual patrols would be necessary and what the additional costs would be. Nor was there any cost breakdown of the other functions of the visual detection system that would have to be conducted in another way such as: weather data collection; communication relay; and extra flying time and equipment needed by suppression crews to find fires shown on the I/R imagery. The cost of I/R detection in Canada will be much higher mainly because of higher aircraft costs. But there is also a problem in the northern territories where the time of ideal I/R detection is limited by the short nights. Considerable daytime flying would be necessary and supplementation accomplished by visual patrols during the late evening and early morning when I/R systems are least effective. Fire detection with the FFS II system could perhaps be compared with aerial photography. One has to photograph the entire protection area to find a fire and this needs to be repeated for each subsequent observation.

AUXILIARY I/R INSTRUMENTS, THE AIRBORNE FIRE SPOTTER[5]

The Northern Forest Fire Laboratory in Missoula developed and tested a simple I/R device designed to locate latent fires and hot spots that are

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[5]The Airborne Fire Spotter is available from:

Ahearn & Soper,	Ahearn & Soper,
844 Caledonia Rd.,	1680 Gillmore Ave.,
Toronto, Ontario.	Burnaby 2, B.C.
Telex Ahsop 02-2757.	Tel. 604-291-0214.
Attn: Joe Paul.	Telex Western Enterprises Westel 04-53237.
	Attn: Al Cornish.

Price of a complete unit is:
(Canadian) $3,295 (excluding tax) or
Rent: $403 per month plus shipping and other charges of approx. $80.

known or suspected to exist but do not emit enough smoke to be spotted visually. This instrument is now commercially manufactured by Barnes Engineering at Stanford, Connecticut, U.S.A. and marketed as the "Airborne Fire Spotter" Model 19-211. It appears that the "Airborne Fire Spotter" will find a good measure of acceptance by many fire control agencies in the future mainly because it is commercially available at a relatively low price. The scanner is subject to a number of limitations, but despite this, it should improve the detection performance of aerial patrols and speed up locating of hard-to-see fires. There is room for an "Airborne Fire Spotter" in every forest service.

1. Scanner Installation.

(a) The scanner head is mounted externally on the wingstrut, fuselage or helicopter skid, subject to M.O.T. approval. It is important to have a 120° unobstructed scan angle and to keep the scanner head away from exhaust gases, engine heat, propeller blast and other phenomena that could trigger the scanner. The mounting of the scanner is particularly tricky on helicopters. Ready made F.A.A. approved mounting brackets are available from:

Johnson Flying Service Inc.,
Municipal Airport,
P.O. Box 1366,
Missoula, Montana, U.S.A.

The scanner indicator unit goes inside the air craft and can be held on the observers lap or be strapped to his thigh.

(b) Since the scanner unit comes with its own cables, only a "plug in" into the aircraft electrical system is necessary. The plug should be installed past the radio noise filter. The cable from the scanner head can be led through an inspection hole into the aircraft's fuselage.

(c) Voltage requirements: either 12 volts dc, 12 watts, or 24 volts dc, 24 watts.

2. Recommended Flying Height.

Flying height is 1000 to 2000 ft. above ground.

Note: Gaps in the scan grid will develop if the aircraft flies faster than 80 miles per hour and less than 500 feet above ground.

3. Application.

The scanner is suited to:

(a) Detect hot spots that no longer smoke enough to be recognized visually;

(b) Check out brush disposal projects;

(c) Check out fire boundaries in smoked in areas; or

(d) Detect hot spots ahead of fire lines.

The Airborne Fire Spotter can detect a 1 square foot hot target from 2000 feet altitude above target.

4. Limitations of the Airborne Fire Spotter.

Perhaps the major drawback of the fire spotter is its susceptibility to false alarms. It was found that the fire spotter can be triggered by:

(a) Fluctuations and interferences in the aircraft's electrical system caused by radio transmissions, manipulating switches, navigation lights, etc.

(b) Interferences from electrical sources outside the aircraft (radar beacons).

(c) Reflection from objects on the ground (bodies of water, metal roofs, greenhouses, oil tanks, rocks, etc.).

(d) Reflections from aircraft parts or direct sunlight.

(e) Hot air from the engine or exhaust gases.

As all I/R devices, the fire spotter must have a direct line of sight to the target; any obstruction, clouds, foliage or duff could cause a missed target.

5. Training of Operators.

The Airborne Fire Spotter needs a trained operator who understands the principles of I/R scanning. He should know the instrument well enough to differentiate between false and real alarms. Before the operator goes on his mission he should have a briefing session, that familiarizes him with the problems ahead. Training films could be obtained from either:

Aerojet General Corporation,
Public Relations Department,
1100 West Hollyvale Street,
Azusa, California 91702.

or the

Boise Interagency Fire Centre,
USDA Forest Service,
3104 Airport Way,
Boise, Idaho 85705.

FIRE MAPPING THROUGH SMOKE WITH I/R SYSTEMS

Large fires sooner or later reach a stage when smoke accumulations prohibit the mapping of the fire perimeter and gathering of intelligence by conventional means. Fire mapping through smoke or at night is one of the truly proven applications of I/R scanning systems. Most systems are of value in such situations, but obviously the more sophisticated systems can do a better job. If one only wants to learn whether the fire has progressed beyond a certain location, the Airborne Fire Spotter might be sufficient. To obtain a detailed map of a major conflagration with the entire countryside covered in smoke, a system with the capabilities of the FFSII complete with Doppler navigation system is barely adequate. Nevertheless, most of the I/R devices available now, other than the FFSII, are systems built with other applications in mind and therefore of limited use for fire mapping.

Available I/R Mapping Systems and Costs:

(a) Proto types.

(The FFSII bispectral system is well suited for fire mapping).

i. FFSII Northern Forest Fire Laboratory

USDA Forest Service,

Missoula, Montana.

Cost: $134,000 (US)

ii. H.R.B. Singer, Reconofax XI

Boise Interagency Fire Centre,

USDA Forest Service,

3104 Airport Way,

Boise, Idaho 85705.

Cost: Estimated $100,000 (US)

(b) Commercial Models.

i. "Fire Mapper"

Computing Devices of Canada Ltd.,

P.O. Box 508,

Ottawa 4, Ontario.

Cost: $40,000 (Can) plus extras.

ii. Bendix Thermal Mappers

(can be modified for fire mapping)

Aviation Electric Ltd.,

200 Laurentien Blvd.,

Montreal, Quebec.

Sales Rep: Terry Malone.

Telephone: Toronto 416-368-7519

Montreal 514-744-2811

Cost: $50,000 and upwards depending on extras.

iii. Daedalus I/R Scanning Systems.

Daedalus Enterprises Inc.,

Box 1869,

Ann Arbor, Michigan, 48106.

Telephone 313-769-5649.

iv. Surplus Military I/R Scanners.

(can be modified, availability and price not predictable)

AAS/5 - Model of a military I/R scanner. Other models exist and could become available for the civilian market.

v. There are no doubt other I/R scanners in existence but no information is presently available.

l. Performance Requirement of I/R Scanners for Fire Mapping.

The performance requirements of I/R mapping systems were discussed at length at the symposium. While most of the discussions centered around the I/R systems developed in Missoula (FFSII, HRB Singer Reconofax XI) a number of points were touched that are universally applicable.

An I/R scanning system used for fire mapping should meet the following standards:

(a) It should have some sort of near real time printout so the operator can see what he is scanning and can adjust his gain control to get maximum resolution of the desired target.

(b) Alternately, there must be some device through which the operator can see the target or which allows him to know when the target is reached, since he cannot see the ground.

(c) Angular and thermal resolution must be such that all the information needed to fight the fire can be obtained through the I/R imagery. Such information would be:

i. the fire perimeter,

ii. the fire intensity along the perimeter and inside the fire,

iii. the type and extent of the remaining fuel inside the fire,

iv. the location of spot fires outside the fire perimeter,

v. fuel outside the fire perimter,

vi. fire lines and fire breaks,

vii. man made structures, buildings, oil tanks, etc.

It might be possible to obtain some of this information in extra runs over the fire and by varying the recording threshold of the scanner. In any case, the sensitivity of a mapping scanner should be better than 4 milliradians and 2 centrigrade degrees.

(d) I/R mapping systems should be equipped with a "Target Discrimination Module" to recognize small spot fires outside the fire line and a film marker to separate one flight line from another.

(e) The scanner's imagery should be as distortion free as possible. A roll compensator is highly desirable.

2. Mechanics of Fire Mapping.

I/R mapping missions handled by the Missoula team are based on a standardized request submitted on a form. The form gives the fire location, the ground elevation, high obstructions near the fire, the main target, the requested information, the drop area for the imagery, etc. The I/R team handles only the I/R aspects of the mapping projects. In the past years the Reconofax XI out of Boise, Idaho and the FFSII out of Missoula accomplished all I/R mapping missions called for in the northwestern United States and Alaska. If the Reconofax XI is activated, polaroid photos of the imagery can be obtained over target and dropped through a special drop tube ejector chute.

FUTURE DEVELOPMENTS AND MISCELLANEOUS FIRE DETECTION MATTERS

1. Future Developments.

Fire Detection Satellites:

With the present state of the art there is little chance that satellite fire detection will become a reality in the next 10 years (Stan Hirsch).

Radar for Fire Detection (SLAR-Side Looking Radar):

Radar is an excellent tool for mapping but it is not suited for fire detection.

Microwaves for Fire Detection:

Microwaves are heat sensitive and appear to have fewer disadvantages than I/R. Microwave detectors will work through clouds but have poor overall optical resolution. Research is in progress on this subject.

I/R Ground Scanners:

Does not appear practical - as horizontal penetration through timber is nearly impossible.

Chemical Sensors:

Gases and particles of the combustion process in the rising air can be sensed remotely from a distance of up to 10 miles. Development work is in progress (Barringer Research Ltd., 304 Carlington Drive, Rexdale, Ontario, Canada).

Remote Observation by Television:

Videocon cameras "see" less than a man and it still takes a man to watch the screens. Unless such a system is much cheaper than a manned system it does not warrant consideration.

2. Current Fire Detection Matters.

Fixed detectors versus aerial patrols:

Both methods have advantages and disadvantages. Some agencies in the U.S. lean toward one system or the other. Eleven agencies do not maintain any kind of detection system and rely exclusively on the public to report fires. It was apparent that although more and more agencies are favouring aerial patrols at the expense of lookouts, the "air patrollers" are still in the minority. Nevertheless, there are already some 34 "all air patrol" agencies in the U.S.

Type of Aircraft Used for Patrols:

Many types of aircraft are used for patrols, from the "Super Cub" to the Lear Jet. Some agencies patrol storm paths with a 204 B helicopter complete with suppression crew. As a rule, the patrol aircraft seldom leave their patrol route to do other work.

Lookouts:

It was agreed that lookouts are an expensive means of fire detection, however, it is the only detection medium providing continuous observation.

Testing of Lookout Men:

It was mentioned that the smoke test for lookout men or aerial observers is not a valid test. The efficiency of observation personnel seems to improve considerably once they are cued by storms or hazard conditions.

Visible Area Mapping:

A process of constructing visible area maps by computer was presented. The system employed elevations taken from 1:50,000 contour maps spaced in a square grid pattern of 1000 meters. None of the maps produced by this method was available for examination.

Ideal Discovery Acreage:

No definite acreage was named, except that depending on conditions the acreage must be small enough to achieve control within an acceptable time span with available suppression capabilities. The opinion was voiced that the progress made in suppression methods has outpaced the progress in detection methods.

CONCLUSIONS

It appears that it is now technologically possible to locate lightning storms remotely and to identify and count lightning with electronic systems. (Instruments to collect other weather data are already being offered commercially). The cost of such systems would be directly related to the size of the area to be covered.

Infrared scanning systems have advanced to a point where it is now possible not only to map fires or to locate fires in suspected areas but also to take care of primary fire detection, particularly when visual means of detection are frustrated by heavy smoke or darkness. An inexpensive I/R instrument, the "Airborne Fire Spotter" designed to supplement the human eye is being put to use in some areas. Except for the "Airborne Fire Spotter" the adaptation of any of the new hardware will entail large capital investments and high operating costs.

It is expected that the adaptation of the new equipment will allow a decrease in existing installations and personnel (it will not replace it altogether) resulting in some savings in these sectors, but it is unlikely that the overall fire detection costs will decrease, at least not in western Canada. On the contrary, the addition of the new equipment will cause a rise in overall detection costs but will also improve and extend the capability of the detection system. Thus, savings should accrue from saved forest resources and lower fire fighting costs.

Most of the equipment discussed at the seminar has wider applications than fire detection or fire mapping, and it does not appear economically justifiable at this time to acquire such equipment for the exclusive use of one fire suppression agency. It will be necessary to assess the individual needs of each potential user and single out a system that is capable of meeting most needs. Such a system could be acquired and operated on a national or regional basis and be made available to interested agencies on a cost sharing scheme to do the work that these agencies require.

Any automated weather equipment should be capable of providing all the data needed for weather forecasting, computing the Forest Fire Weather Index and fire detection patrols. The entire instrumentation should be planned as a part of a system in order to eliminate duplication.

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