FIRE CONTROL NOTES

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FIRE CONTROL NOTES

A quarterly periodical devoted to forest fire control

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Cover—Construction slash along road corridors between cutover areas is fuel for wildfire. Besides being an eyesore, it can create problems in future timber harvesting. See story next page.

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Road Construction Slash . . . Potential Fuse for Wildfire?

John D. Bell [1]

Slash from road construction is likely to serve as a connecting link between patches of highly flammable fuels, such as clearcut units. Increased "fire rate of spread" and increased difficulty in using roads to move men and equipment often result.

Construction debris along permanent and spur logging roads can be a fire hazard if slash is not adequately disposed of during road clearing. Roadside slash includes cull logs, branchwood, snags, brush, and other vegetation (cover). Besides its high fire hazard potential, roadside debris is esthetically unattractive. And where right-of-way material is piled against standing timber, it can create problems for future harvesting.

In the Douglas-fir region, construction slash on interlinking roads between freshly logged patch cuttings has served as a connecting fuse for the spread of wildfire.

Raft River Fire, 1967

An example of a fire spread by right-of-way slash is the Raft River Fire of July 1967. This fire started on private land within the Quinault Indian Reservation in northwest Washington after several weeks of dry, warm weather and fire danger buildup. The fire started on a clearcut logging operation in heavy slash and spread over 4,500 acres during a 4 day period. Northwesterly winds fanned the flames through the heavy slash in the cutover areas, but spread was usually checked by the adjacent green timber. More than 85 percent of the area burned was untreated cedar and hemlock logging slash. The remaining burned acreage was reproduction and old-growth timber — mostly fringe areas around clearcut boundaries and along the edge of connecting roads between units. In a number of instances, firefighters reported that the fire funneled from clearcuts into road corridors and then spread rapidly through construction slash into adjacent clearcut units (fig. 1). They also observed spot fire ignitions in the roadside slash with subsequent rapid linear spread. The intense heat and smoke from fires along these connecting roads hampered movement of men and equipment to control the fire.

Action Planned

Construction slash should be of concern to agencies responsible for forest protection. In Oregon and Washington, the Forest Service is now in the process of revising its regional slash disposal policy to improve and update fuel treatment methods. Included in the policy now being formulated are requirements for complete disposal of all road construction slash in Land Management Units (LMU) and on Land Access Roads (LAR) in the National Forests. Roadside slash cleanup will contribute to safer, more effective fire control where forest roads are used directly as control lines. In addition, the possibility of fire spread through roadside slash corridors will be reduced. △

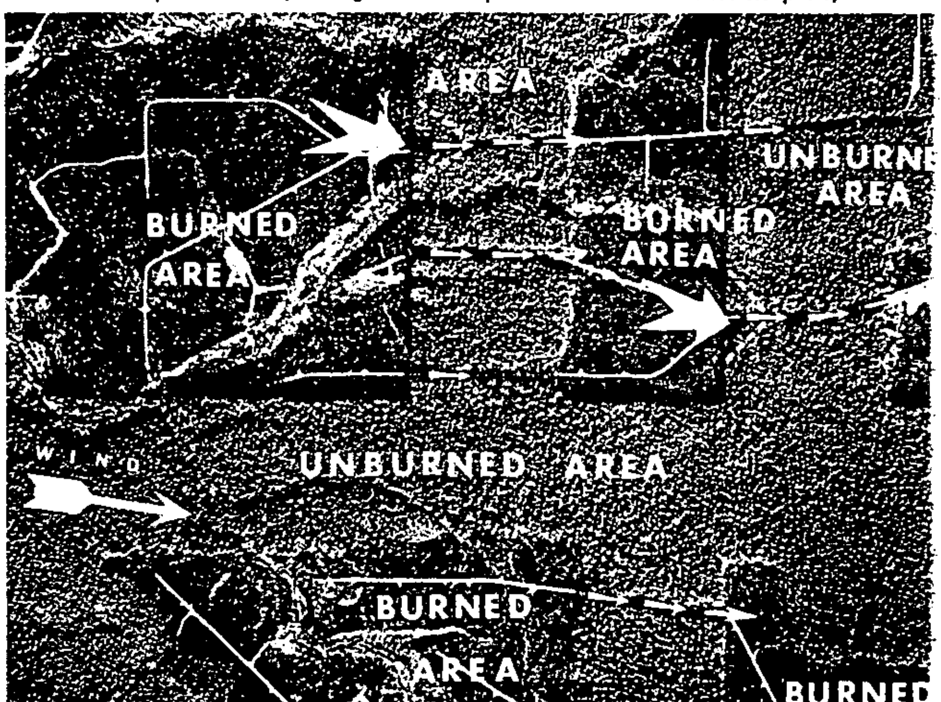

Figure 1—Portion of the 4,500-acre Raft River Fire. The two large arrows show where the hot slash fire funneled into the road corridor, spread along the construction debris, and swept into adjoining cutovers, where topography was nearly level. The distance between cutovers is one-quarter mile. (Washington State Department of Natural Resources photo)

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Automated Forest Fire Dispatching

. . .. A Progress Report[1]

ERNEST T. TOLIN, JAMES B. DAVIS, AND CONRAD MANDT[2]

Computers may offer a way of speeding up forest fire dispatching. Results of tests made on a prototype system suggest that automated fire dispatching is feasible and can be a useful tool to both the skilled and unskilled dispatcher.

Time was when forest fire control "dispatching" meant impressing into service any unfortunate soul who happened to be near the fire. Today, impressing is no longer done. Instead, most dispatchers control large, complex organizations already set up that include men, vehicles, and aircraft. The dispatcher has the problem of keeping track of these resources, and he must move them quickly and efficiently to a fire.

Computer technology may offer a solution to this problem. A switch to automatic data processing is not justified, however, merely because it is modern technology. The computer must prove itself "cost effective"; it must make dispatching cheaper, faster, or more accurate.

Any system, if it is to be the most helpful to the dispatcher, must:

- Give more information than even a skilled dispatcher might normally possess and give it quickly.
- Yield a permanent written record at least as good as the log now kept by hand.
- Keep an up-to-the-minute record of location and strength of all firefighting resources.
- Help in planning crew locations, road system modifications, and other potential changes.
- Be useful as a training aid for new personnel.

From a practical viewpoint, a system should be designed so that it meets all of these requirements with existing personnel and a budget that a forest fire control organization can afford.

WHAT RESEARCH IS DOING

The idea is to have a command and control system for a dispatch office that can weigh the cost of fire suppression against values protected. The system would be able to consider variables of topography, weather, fuels, and resource values and then recommend the dispatch of those fire fighting resources best able to control the fire. (1–4)

This paper reports the first of a series of steps aimed at reaching this goal. A prototype system was developed and was tested during the 1968 fire season. Our objectives were to (a) define dispatcher needs and specify requirements for an operating system; (b) determine the feasibility of computer dispatching; (c) develop a prototype computer dispatch system that will use network or graph theory; and (d) test the feasibility of a remote computer terminal operating from a central time-sharing computer.

Specific Requirements of the System

Besides providing estimated time of arrival at a fire and recommended travel routes, an automated dispatch system must be able to store and retrieve information on firefighting resources by providing for:

- Up-to-the-minute display of available firefighting resources.
- Easy update of the inventory when resources are transferred from one site to another.
- Ability to account for resources transferred in or out of the dispatcher's area of control. (This quality would be particularly important for keeping track of large quantities of resources used in combating a major fire.)
- Inventory of resources that have been assigned to a fire. (The skilled dispatcher may know local resources and their travel routes and times to any fire within his area, but few dispatchers can keep track of the identity and disposition of outside forces brought in during emergencies.).
- Printout, on demand, of forces assigned by cooperating organizations.

In the summer of 1968, the Pacific Southwest Forest and Range Experiment Station joined forces with the California Division of Forestry in developing and testing a prototype system. The test was held in an area assigned to the San Bernardino County Ranger Unit.

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[1] This article first appeared in FIRE TECHNOLOGY, May 1969.

[2] Respectively, computer-programer and project leader, Forest Fire Laboratory, USDA Forest Service, Riverside, Calif.; and highway engineer, Transportation System Planning Study, Division of Engineering, Region 5, USDA Forest Service, San Francisco, Calif.

From the results, we concluded that automated dispatching is feasible and can be a useful tool. Its importance to a fire control organization, at least in the initial stages, is probably inversely proportional to the skill of the dispatcher; that is, an unskilled dispatcher probably needs the system more than a skilled one. The system becomes more useful as fire complexity or load increases, and it should be helpful where there are mutual-aid arrangements or overlapping jurisdictions. But we have a long way to go in speeding up the system's response time and in making it "fail safe." We found that the computer was used much more than we had ever anticipated. Dispatch and subsequent follow-up dispatch action form a complicated process involving continual dialogue with the computer during the life of the fire. Consequently, the computer becomes a colleague rather than a tool for the dispatcher.

Test Area

The organization selected for the test—the San Bernardino Ranger Unit—protects an area that has many fires and some of the world's most valuable watershed land. The Unit controls a large number of firefighting resources and has developed strong mutual-aid agreements. The interest and progressive attitude of the ranger and his dispatch staff were important factors in our decision to test the system here. The California Division of Forestry spent several weeks in measuring travel times and inventorying the equipment to be used in the system.

Computer Hardware

Initial versions of the computer program were developed on IBM 7040 and CDC 6400 computers. Both machines were owned by the University of California.

We decided to use a commercial time-sharing service for the prototype system. These services use terminals, little more complicated than electric typewriters, that are connected by regular telephone lines to a computer center. Since a single large computer can service many such terminals, its cost can be shared, making the service available to a large number of users who could not otherwise afford computing equipment. Once the programming job has been done, time-sharing allows the use of normal language. The user can talk freely with the computer in ordinary English by typing on the keyboard. The typewriter is fast enough for most uses—as fast as 15 characters per second. At this rate, information can be transmitted by conventional commercial telephone lines. (5) All the dispatcher sees, then, is a typewriter on his desk tied into his telephone system. However, he is connected directly to a computer—in our case 70 miles away—capable of making mathematical computations in billionths of a second (fig. 1).

Our next step was to analyze commercially available time-sharing systems. (6) Many factors had to be considered, including computer core size, access to storage, load and compile time, reliability of the system, and the time that the system would be available. We contracted with the Allen-Babcock Computing, Inc.

HOW THE SYSTEM WORKS

How does our computer program work? The crux of the problem is to get men and equipment from one place to another as quickly as possible. The computational procedure used by the computer is based on network or graph theory. (7) When we talk about graphs,

Figure 1—Operator gives instructions to a time-sharing computer, located 70 miles away, by typing on an electric typewriter. Telephone lines connect this terminal to the computer.

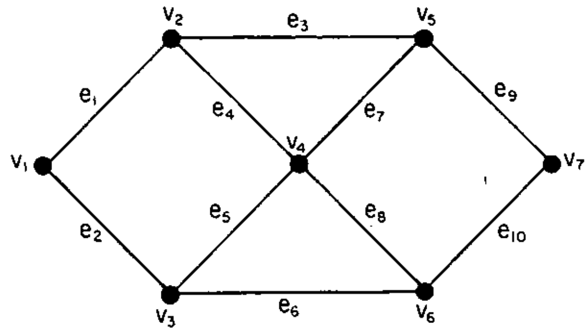

Figure 2—Simple network or graph shows 7 nodes connected by 10 links.

most of us picture a chart showing the interrelation between a set of variables. The kinds of graphs we are using, however, are geometric structures consisting of points (nodes) connected by a system of lines (links). (8-10) The interrelation of these nodes and links forms a network that can be an abstract concept or a model of a real situation, such as a pipeline complex, an electrical system, or—as in our case—a network of roads (fig. 2).

Mathematical Theory

Pairs of nodes are connected by links to form a network. A path can be formed from a point to any other point in the network. Each link has a travel time from one end to the other that may be different in each direction and in each time interval. For forest roads or trails, each junction would constitute a node.

If no cycles, or distinct paths, lead from a node back to the same node, the network is called a tree. A tree that reaches all of the nodes of a graph is called a spanning tree (fig. 3). The simplest tree graph is a line connecting two nodes but the number of possible trees increases rapidly as the graph increases in size. For example, four nodes can be connected in 16 possible ways. Consequently, there may be hundreds, perhaps thousands, of different spanning trees within our 158-node forest road system. There is ususlly one best spanning tree. (11) The computer must pick, out of all the thousands of combinations, the one best spanning tree (12, 13) This best or "minimum spanning tree" will show the route that fire equipment should use when going to any fire within the forest area covered by the network.

For practical purposes then, the forest fire or administrative road system can be compared to a graph. The intersections and other points of interest may be considered nodes. Each node is assigned a code number. The interconnecting roads are the links. Some nodes represent actual fire control stations; others represent key areas near which fire suppression crews may be operating. But we do not have to limit ourselves to regular agency crews. We can consider any firefighting force, such as logging crews, public utility crews, and equipment of cooperating agencies.

A necessary feature of the system is that crews can be readily reassigned throughout the area. Each crew is assigned a code number. To reassign crews the dispatcher follows a simple updating routine on his typewriter. For the most part, crews will represent fire control forces within the dispatcher's normal span of control. Empty or unassigned nodes within the network are not recorded within the computer's equipment register. (14) The location of a node in the network shows the computer where to look in its disk file for an accurate description of the equipment at a particular location.

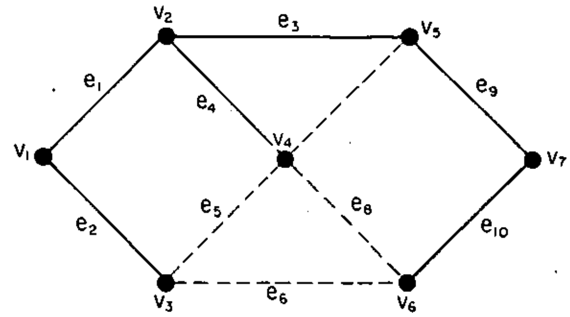

Figure 3—Lines indicate a spanning tree or a minimal connected graph.

Computer Response

Within the computer's memory, each word of information is given a number by which it is identified. This number is called its address. Access to a particular word of memory is achieved by specifying an address as a binary coded number. The prototype system uses a random access disk. Access time to the disk does not depend on the sequence in which the words are entered or extracted. By using the equipment-filing system housed within the computer memory, we can rapidly update information on the disk. When a crew is dispatched from its present location to the fire or to another location, the dispatcher updates the computer record by typing in the crew's code number and the code number of

the new location. The actual dispatch goes through these steps:

• The computer calculates the minimum travel times from all nodes to the fire using the spanning tree algorithm. Instead of printing out this information, however, the computer retains it in temporary storage.

• The computer then examines travel times, finds the shortest time, and searches the equipment register for possible resources. When it locates a piece of fire equipment that is closest to the fire, it automatically gives a recommended dispatch for that piece of equipment. The computer repeats the sequence until either all resources are located or the dispatcher stops the procedure.

• Finally, resources, their locations, travel routes, and travel time to the fire are printed out (fig. 4). The format can be modified as experience in dispatcher requirement is gained.

WHAT WE LEARNED

The system began operating on August 13, 1968. For an average 15- or 20-acre fire, the dispatcher used his terminal for about 100 minutes. The computer center was called 1,325 times during the 1-month period in which 60 fires occurred (not all of these calls were for fire control—program modification and demonstrations to "visiting firemen" were also involved. Lapsed time from a call until the computer answered averaged 1 minute 23 seconds. Ideally, the dispatcher would like to have his answers in about 4 to 5 seconds.

The relatively long time required by the prototype system included several seconds needed to dial the computer center and time required to log into the center and call up the dispatch program from the system's disk file. The dispatcher took additional seconds to type in fire location and other procedural instructions. Finally, the computer had to calculate the quickest route from the crew locations to the fire.

Consequently, when a dispatcher received a fire call, he sent some of his initial-attack forces and, about the same time, dialed the computer. By the time the first two or three crews were underway, he was beginning to get a response from the computer. He would then ask the computer for follow-up dispatch information. He would begin to update his equipment inventories, perhaps make a second follow-up dispatch if conditions warranted it and, again, update. Then he might call for a status check on the location of all equipment.

Perhaps equipment from outlying stations was moved to those vacated for the fire. Equipment was often released in several steps. Some equipment would be returned directly to its home station, while other items might be transferred elsewhere or even sent to a second fire.

This movement resulted in far more use of the computer than we had anticipated. The system holds promise of being a much more useful, and consequently more valuable, tool than we had expected. On the other hand, it made our test program more expensive than we had anticipated.

At prevailing rates, it costs about $100 to make a dispatch to a 15-20-acre fire. But $100 could also buy about 5 hours of D-8 bulldozer time or a couple of hours of 25-man crew time.

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```
\XEQ GO
DO YOU HAVE A FIRE ??
\YES
WHERE IS THE FIRE
\HOME
\75
ENTER 0 TO SUPPRESS ROUTES ELSE ENTER 1
ENTER NO OF RESPONSES YOU WANT FROM TO
\COLST
\1,1,3
690107     1030
RESPONSE NO. 1. IS FROM NODE 2.  ETA IS 3.  MIN.
TRAVEL IS FROM NODE 2.   TO NODE 78.
               NODE 78.  TO NODE 75.

EQUIPMENT AT THIS STATION IS:
          571    CDF FTH 500 GAL

690107     1030
RESPONSE NO. 2. IS FROM NODE 18.  ETA IS 8.  MIN.
TRAVEL IS FROM NODE 18.  TO NODE 57.
               NODE 57.  TO NODE 58.
               NODE 58.  TO NODE 59.
               NODE 59.  TO NODE 75.

EQUIPMENT AT THIS STATION IS:
          283    CDF FTH 500 GAL

690107     1031
RESPONSE NO. 3. IS FROM NODE 5.  ETA IS 9.  MIN.
TRAVEL IS FROM NODE 5.   TO NODE 85.
               NODE 85.  TO NODE 75.

EQUIPMENT AT THIS STATION IS:
          589    CDF FTH 500 GAL

          060    CDO FTH 500 GAL
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Figure 4—Dispatch order and reassignment of fire fighting forces may be printed out by the typewriter terminal in this form.

Thinning Slash and Fire Control

ROBERT W. APPLEBY [1]

The effect on fire control of thinning timber stands cannot be generalized. The results must be considered as applying only to the topography of a given site and only under the stand conditions and fuel factors that exist on that site.

[Editor's note: Robert W. Appleby's article is in response to an invitation to comment on an article by Robert Cron in the Winter 1969 issue of *Fire Control Notes* (Vol. 30, No. 1). The subject of Cron's article was thinning and its effects on fire control (Thinning As An Aid to Fire Control, p. 3).]

As Robert Cron's article in *Fire Control Notes* points out, there have been many debates regarding the relationship of thinning slash to fire control. I do not believe Cron's article really deals with the thinning slash problem in itself, but simply compares observations of fire actions in a pole and sapling stand and a stand that was thinned. Most people would agree that it is easier to build a dozer line through a 2- or 3-year old thinned stand than through a green, uncut stand—all other things being equal. This is simply a matter of mechanics.

In many situations, I am sure that expert fire control men would rather burn out from a line in thinning slash than they would in some pole and sapling stands. Here again, each situation is different.

Determination of fire behavior in any particular situation is not unlike determining a stumpage price through the appraisal system. There must be a complete analysis of the data affecting all the factors of the operation before the proper decision can be made.

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Figure 1—Ponderosa Pine Thinning Slash.

What We Need to Know

Following are some of the facts we need to know in making a true comparison of fire control in thinned and unthinned stands:

1. What was the weather situation at the time of each burn situation?

2. What diurnal weather changes were involved? The burning index drops off sharply after the middle of the day, and thirty minutes could make a considerable difference in burning conditions. Because the thinned area burns, as pointed out in Cron's article, were evidently later than the unthinned stands, this could have been a factor. (1)

3. What was the topography in front of and behind each fire situation?

4. What were the fuel conditions in each area burned?

5. What temperature, wind, and humidity occurred during the two situations?

6. What tonnage of fuel was on the ground below the pole and the sapling stand?

7. What was the age, species composition, average diameter, number of stems per acre, and ground cover in each situation? Rate of spread and resistance to control depends on these elements. (2)

8. What was the moisture content of each fuel situation? In a season such as 1967, the moisture content in evergreen foliage is considerably reduced. (3), (4)

9. What was the temperature of the fuel under each burning situation? Cron points out in one instance that green brush (mostly alder) was growing heavily as an understory beneath the thinned larch. This could change the

thinning slash combustion characteristics if the facts here were known.

10. What where the fuel type ratings in each situation? Fire control action is principally based on two elements, namely, rate of speed and resistance to control.

The combination of factors that determines the rate of spread of a fire and the resistance to control are complex, variable, and interrelated. Most observations, whether they favor thinned or unthinned stands, are observations relating to large fire control.

Controlling a large project fire and controlling a small fire have entirely different management considerations. (4) While thinning slash may not be a serious problem in building a fireline a mile away from the fire front with d-9 dozer, it will have a serious effect on the ability of two men with axes and shovels to construct a line. The rate of spread factor of fuel is more a matter of logistics in the case of a large fire, but when a high or extreme rate of spread is present on a small fire, and a few men are involved, it is a matter of immediate concern and dictates whether the fire is able to be controlled within standards.

Policy

It is Forest Service policy to attack a fire when it is small and control it while it is small. In pole stands, this usually means a ground fire or an occasional flare-up in a thicket when ground fuels are heavy.

I would not say that the Forest Service will have this policy forever, but until the basic fire factors of fuel and weather can be better controlled, it would not seem prudent to let the small fires become large and attempt to control all of our fires after they become large.

Table showing comparison of factors relating to rate of spread in thinned and unthinned areas.

Factors	*Thinned Area Fuel*	*Unthinned Area Fuel*
Fuel, moisture content	Dry	Green
Fuel, density	More Compact	Spread over more space
Fuel temperature	Higher	Lower
Wind	Less restricted	More restricted
Air temperature	Higher	Lower

Assuming, then, that we are going to attempt to control fires when they are small, let us look at the basic change in fuel and environmental factors caused by saw thinning. Let us try to visualize 10 acres of Ponderosa pine (saplings), flat ground, 4,000 stems to the acre, no fuel on the ground except light needle and duff cover.

The table lets us compare just those conditions we change by the act of thinning.

All these factors show that a fire will start much more readily in dry slash. Therefore, the risk of fire is increased considerably.

In looking at the rate of spread factors, I think most foresters would agree that dry fuels burn better than green fuel, that the compacted position permits greater fire intensity, and that ignition is more rapid and the fire burns hotter in an environment where higher temperatures and wind are permitted.

The resistance-to-control factors are based on fighting a small fire, and the jackstraw position of the thinned material creates a difficult job in constructing a line by hand, even with a powersaw. Constructing a hand line through a pole stand with the fire on the ground is much faster and easier.

A Shortcoming

A serious shortcoming, in my opinion, in making decisions relating to slash disposal has been the constant reference to the relationship of the new hazard to the old hazard. You continually hear the argument that the stand was a serious

Figure 2—Area treated with mechanical brush cutter.

fire hazard before the silvicultural operation, so why are fire people worried about the new hazard. This philosophy is comparable to the fellow who buys a houseful of termites and because they have been there for years, he doesn't believe it is necessary to eliminate them now. A common question asked is: Would you rather fight fire in a dog-haired thicket or in a thinned stand? The question is academic. My answer is that I would rather not have to fight fire in *either* situation. It seems to me that it ought to be National Forest management's objective to take steps to insure the lowest calculated risk of having serious large fires in stands where we have invested many dollars per acre.

This risk can be lowered at a reasonable cost by treating the slash in order to give us a rate of spread and resistance to control in which a fire can be controlled within policy standards.

The results of one slash treatment method are shown in the photograph below. (5)

Chemical thinning and machine swamper burning are other ways in which to reduce the hazard.

I think we should consider what problems develop and base our decision on the situation as it exists. If a Region is considering thinning fifty to a hundred thousand acres or more, the created fuel types of HH rating or above cannot be reasonably protected. The manpower, equipment needs, and costs to control fires in these fuel types within present standards would be exorbitant. At the same time, the risk of losing these stands would be very high.

References

(1) Barrows, J.S., Fire Behavior Northern Rocky Mountain Forests, Northern Rocky Mountain Forest and Range Experiment Station. Station Paper No. 21, 1951.

(2) Fahnestock, George, Fire Hazard from Precommercial Thinning of Ponderosa Pine, Pacific Northwest Forest and Range Experiment Station, Research Paper No. 57, 1968.

(3) Intermountain Forest and Range Experiment Station, Annual Report, 1934, p. 14.

(4) Davis, Kenneth P., Forest Fire Control and Use, 1959, McGraw-Hill Book Co., New York, p. 91, 97-98.

(5) Dell, John and Ward, Frank, Interim Report—Reducing the Fire Hazard in East Side Thinning Slash by Mechanical Crushing, July, 1968.

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Obviously, then, under present costs, computer dispatching is feasible, but just not practical. But remember, our prototype system is unrefined and includes what might be termed research and development costs.

WHAT WE DO NEXT

We plan to continue the development of the prototype dispatch system in the following ways:

- Improve programing — we have the means to reduce the number of operations, amount of storage space, and time required for the computer to respond.
- Take advantage of the well-established trend toward cheaper, more efficient computer hardware.
- Try out other display systems, such as television screen cathode ray tubes.
- Develop a recommended dispatch model based on parameters of fire spread and fire control force capability. (This model would recognize the serious problems present in developing suitable economic criteria for fire control effort.
- Improve the road system graph to include the differences between classes of vehicles, such as pickups, fire trucks, and bulldozer transports.
- Develop a dispatch model that will weigh the cost of suppression against the values protected.
- Try the system in an area with a different pattern of fire occurrence and fire control resources than the San Bernardino Ranger Unit area.

Although we designed the system for initial attack, most observer interest has been for region or area-wide support dispatching. In many ways the system can perform this task much easier — time requirements are not so severe because travel times are longer, and the computer can be a greater help to dispatchers who cannot become intimately familiar with large geographical areas.

REFERENCES

(1) Heyman, D.P., Least Cost Location of Fire Suppression Equipment, Report ORC 64-4, 1964, Operations Research Center, University of California, Berkeley, Calif.

(2) McMasters, A.W., Wildland Fire Control with Limited Suppression Forces, Report ORC 66-5, 1966, Operations Research Center, University of California, Berkeley, Calif.

(3) Parks, G.M., The Development and Application of an Analytical Model for Initial Attack on Wildland Fires, Report ORC 64-8(RR), 1964, Operations Research Center, University of California, Berkeley, Calif.

(4) Parks, G.M., and Jewell, W.S., A Preliminary Model of Initial Attack, Report F-1, 1962, Operations Research Center, University of California, Berkeley, Calif.

(5) McCarthy, John, Information, Scientific American, Vol. 215, No. 3 (1966), p. 65-74.

DISPATCHING, P. 13

Firebreaks Of Many Uses

HAMLIN L. WILLISTON [1] AND R. M. CONARRO [2]

Permanent firebreaks help protect large, highly flammable plantations while serving an important role in transportation, recreation, and wildlife management. These firebreaks are a cooperative effort of private landowners and government agencies.

Permanent travelable forest firebreaks are necessary to forest fire prevention and suppression on the Yazoo-Little Tallahatchie Flood Prevention Project in north Mississippi.

During the last 4 years, 1,207 miles of firebreaks have been built to help protect the 500 thousand acres of highly flammable, privately owned pine plantations established by the Project. They won't stop a "hot" forest fire without manpower assistance, but they do provide:

a. Quick access for fire suppression (fig. 1).

b. A base for backfiring.

c. A green barrier to slow winter fires.

d. Ways for harvesting forest products.

e. Ways for multiple-use management of the forested property.

f. Winter game food where conditions permit it to grow.

Cooperative Effort

Building firebreaks has been a cooperative effort among the landowners and several government agencies within the Project area, and other organizations may benefit from our experience and guidelines. The landowner must want firebreaks enough to cooperate in their maintenance and to permit the Mississippi Forestry Commission to use them in controlling fires on his or adjoining land. The Soil Conservation Service helps in planning, seeding, and fertilizing. The Forest Service helps in the planning, flags out the rights-of-way, finances some of the land clearing cost, and supervises their construction. The Agricultural Stabilization and Conservation Service provides partial financing, generally about 50 cents per 100 linear feet. The Mississippi Forestry Commission will contract with the landowner to do disking, light clearing, and some ditching.

The effectiveness of a firebreak system depends upon thorough planning. Our plans cover not only an entire ownership but also several adjoining ownerships. (We have firebreaks that extend 6 miles across 17 ownerships.) Planners concentrate on a system that is economical to construct and to maintain and yet is completely serviceable. Good use is made of the old woods roads that abound on the ridge tops in this area. Often rights-of-way for power, pipe, and telephone lines—providing written permission can be secured—are utilized.

In planning, due weight is given to past fire records, management needs, direction of the prevailing winds, topography, and access roads to the system and property. In scouting the route selected from aerial photos, the terrain, condition of the soil, forest canopy, on-the-ground flammable material, and other fire hazards, logical timber harvesting routes, recreational possibilities, potential wildlife openings, natural man-made barriers, and fences are all considered. Routes are chosen to avoid cutting pole-size or large timber and to avoid installing ditches and cross drainages. Steep grades, sharp curves, bogs or marshes, and live stream crossings are avoided. Truck and tractor

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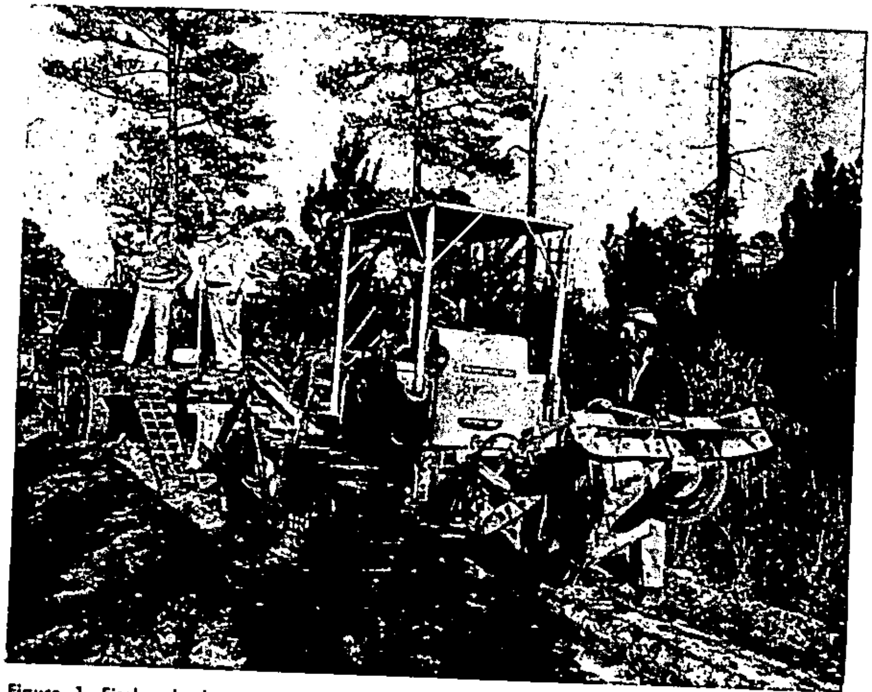

Figure 1—Firebreaks have made many areas that could be reached only on foot easily accessible to fire crews.

turnaround space is provided at dead ends and at about one-half mile intervals along the break.

Cost Sharing

To qualify for cost-sharing under the local ACP Program, the area protected must have a stocking of at least 50 percent desirable stems, and the firebreaks must be located to contribute directly to the protection of the area. Breaks should be 15 feet wide. No part of the breaks will be less than 10 feet wide. The breaks may be located along property lines and throughout the area, but no more than 5 percent of the woodland area may be in firebreaks. The firebreaks must accommodate truck traffic. Lead-off ditches and water bars must be constructed where erosion hazards are created.

Where side ditches are needed, their required space is in addition to the designed traveled width. Where cross drainage is required, the firebreak is widened slightly for a distance of about 20 feet on the high side to provide better protection for the cross drainage entrance.

Firebreak clearing in stands of trees 3 inches and larger in diameter is generally done in the summer using a d-6, or equivalent, tractor and blade. This clearing job can usually be contracted at less cost than hand operations. The maximum distance between surface drainage should be 500 feet where the grade is 2-5 percent; 300 feet where the grade is 6-10 percent. Grades up to 15 percent may be used if their length does not exceed 100 feet. A lateral grade of 3-5 percent is best. Avoid areas with no lateral grade or with lateral slopes of over 10 percent.

Build side ditches only where necessary to drain permanent seeps. Use cross drainage to prevent water from rushing on or across the firebreak. For cross drainage, install an open ditch with rounded edges at an angle of 60 degrees to the center line of the road. This prevents both front or both rear vehicle wheels from being in the low or high part of the cross drainage at the same time.

Soil Cover

To be effective, a firebreak should provide, in addition to a travel way, a soil cover which will be green and non-burning during the winter forest fire months, October 15 to May 15. Seedbed preparation—disking, liming where needed, and fertilizing—should be started in the summer and completed by September 1. Wait at least 30 days before seeding, longer if the weather remains dry. Complete the seeding not later than October 15.

Kentucky fescue (*Festuca elatior* var. *arundinacea*) is one of the main winter plants sown, but it needs renovating after 3 or 4 years. It is a heavy user of nitrogen, phosphate, and potash and requires a pH of 6.0-6.8. White clover, (*Trifolium repens*) or winter peas can be grown in combination with fescue. Fescue needs a moist, well-drained soil and some sunlight for good establishment and growth.

Rye grass (*Lolium multiflorum*) is an annual which will quickly protect the soil. Rye should be used in combination with small grains such as winter wheat (*Triticum aestivum*) and winter peas (*Lathyrus hirsutus*) or with crimson clover (*Trifolium incarnatum*). The seedbed should be cultipacked after seeding. It generally requires two tons of lime

per acre. Rye grass combinations need a light soil disturbance each summer if permitted to go to seed.

Common Bermuda grass (*Cynadon dactylon*) is widely used in open areas in Mississippi. Only firebreaks constructed in areas open to grazing and not shaded should be seeded to Bermuda. Common Bermuda will produce better growth if it is mixed with legumes such as crimson clover, white clover, or winter peas.

Game Management

Many landowners are interested in managing for game as well as timber. Game food plots, not to exceed one-half acre, can be located along firebreaks and sown with the same cover. A scattering of food-bearing plants, if available, should be left on the plots. Mast-bearing trees surrounding the plots should be stimulated to produce bumper food crops by fertilizer applications. A fringe of common lespedezas, reseeding cowpeas, and wild soybeans can be seeded on the plots. Browse plots for deer can be located on the poorer timber sites. Such sites should be cleared of standing trees with the principal objective being to grow a heavy stand of fast-growing sprouts.

Many legumes may be found growing wild near firebreak locations. They provide winter food for quail. Legumes such as rattlebox, wild sweetpea, butterfly pea, and Japanese clover will grow under some shade and may be seeded outside the edges of the firebreak to provide winter food. Blackberries and mulberries are favored quail food and can be grown under partial shade (fig. 2). Common lespedezas, reseeding cowpeas, and wild soybeans provide excellent quail food and are easily established.

Cost

The cost of firebreak construction has run from $60 to $250 per mile averaging about $90. Increased accessibility to their property alone has more than compensated most owners for their investment. Started to protect young flood-control pine plantations, this practice has fitted effectively into a multiple use of land management program. Firebreaks have stopped many slow winter fires and have enabled the State fire crews to quickly get into the "back country" to suppress hot fires. Firebreaks are also being used for pulpwood operations, hunting, access to lake sites, and motorbike and horseback riding trails. △

Figure 2—Quail hunting is excellent along many of the firebreaks.

DISPATCHING, FROM P. 10

(6) Davis, James B. and Nickey, Bradley B., Computer Timesharing—A New Tool for Foresters, (1969), manuscript in preparation.

(7) Dreyfus, S.E., An Appraisal of Some Shortest-path Algorithms, RM-5433-PR (1967), The Rand Corporation, Santa Monica, Calif.

(8) Saaty, T. L. and Busacker, R.G., Finite Graphs and Networks, McGraw-Hill, New York, 1965.

(9) Ore, Oystein, Graphs and Their Uses, Random House, New York, 1963.

(10) Tropper, A.M., Matrix Theory for Electrical Engineers, Addison-Wesley, Reading, Mass., 1962.

(11) Gardner, Martin, Mathematical Games — Combinational Problems Involving 'Tree' Graphs and Forests of Trees, Scientific American, Feb. 1968, p. 118-123.

(12) Johnson, William F., Minimum Path Algorithm for Successive Time Intervals, Department of Civil Engineering, Massachusetts Institute of Technology, 1967.

(13) Pollack, Maurice and Weisbenson, Walter, Solutions of the Shortest-route Problem—A Review, Operations Research, Vol. 8, No. 2, p. 224-230.

(14) Ford, L.R. and Fulkerson, D.R., Flows in Networks, Princeton University Press, Princeton, N. J., 1962. △

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U.S. DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C. 20250

OFFICIAL BUSINESS

POSTAGE & FEES PAID
United States Department of Agriculture

Crawler Tanker-Plow

NICHOLAS LYLO AND
STUART HANNY [1]

The International 500 crawler tractor with a Seico fireplow attached for building fire lines is becoming an important firefighting tool in Pennsylvania. Seven of these machines are in use in the State.

Experience has shown that the addition of a small water supply and a light-weight pump add a safety factor for both the operator and the machine. The personnel of Michaux Forest District of the Department of Forests and Waters tackled the problem of developing such a unit. Their efforts produced the Crawler Tanker-Plow.

Features

The Tanker-Plow unit must have several distinct features:

1. It must be compact, have a water carrying capacity and a method of dispersal.
2. Any modification or additions to it must not interfere with the normal operation or maintenance of the tractor.
3. It must be constructed so that the weight is properly balanced.
4. The Tanker-Plow unit must be easy to assemble.
5. It must be dependable and easy to operate.
6. The cost of conversion must be reasonable.

All these desired features have been incorporated into the Crawler Tanker-Plow (fig. 1). The unit developed by the Department has a water carrying capacity of 62 gallons in a Snyder fuel step-tank. This water can be dispersed either by hand through the use of a backpack tank or mechanically through the use of a gasoline operated pump. To make the unit complete, a tool box was installed to carry small hand tools necessary for minor field repairs. A drip torch for backfiring and burning out the line was mounted on the unit, and a single bit axe was attached on the back of the cab. A light was mounted on the rear of the tractor for night operation. The Crawler Tanker-Plow is complete, compact, and very usable.

The installation of this equipment on the tractor was accomplished without altering the primary purpose of the tractor plow. Normal operation of the vehicle is maintained by simply extending and relocating the control handles and using the tank step as a seat. The weight is balanced by adding counterweights or installing a blade on the front of the tractor. The photographs show that the additions in no way interfere with tractor maintenance. Anyone with some mechanical ability can make the conversion by following plans available from the Pennsylvania Department of Forests and Waters.

Cost

The cost of materials is small in comparison to the overall advantages of the unit and can be purchased for less than $275.00. Labor cost depends on the ability of the person who assembles the unit. Using a skilled mechanic, the cost of assembly and installation should be less than $150.

With two methods of water dispersal, an assortment of hand tools, and a drip torch, this unit is very dependable and has become an important part of firefighting equipment. It provides protection for the unit and operator and provides a water supply in areas inaccessible by other methods.

Plans and parts lists are available from the Pennsylvania Department of Forests and Waters, Michaux Forest District, Route 2, Fayetteville, Pennsylvania 17222

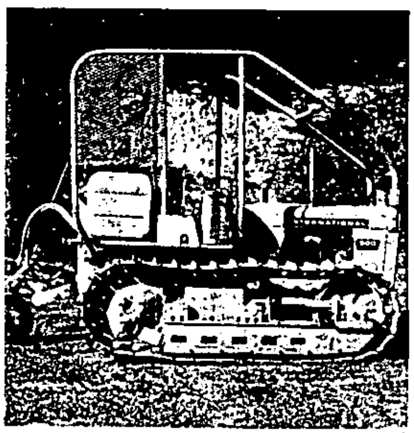

Figure 1—Crawler Tanker-Plow showing end of 62-gallon tank, faucet for filling water cans, coiled discharge hose inside cab grill, and backpack pump.

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